

SPECIAL REPORT: JAPAN

AUGUST 1985

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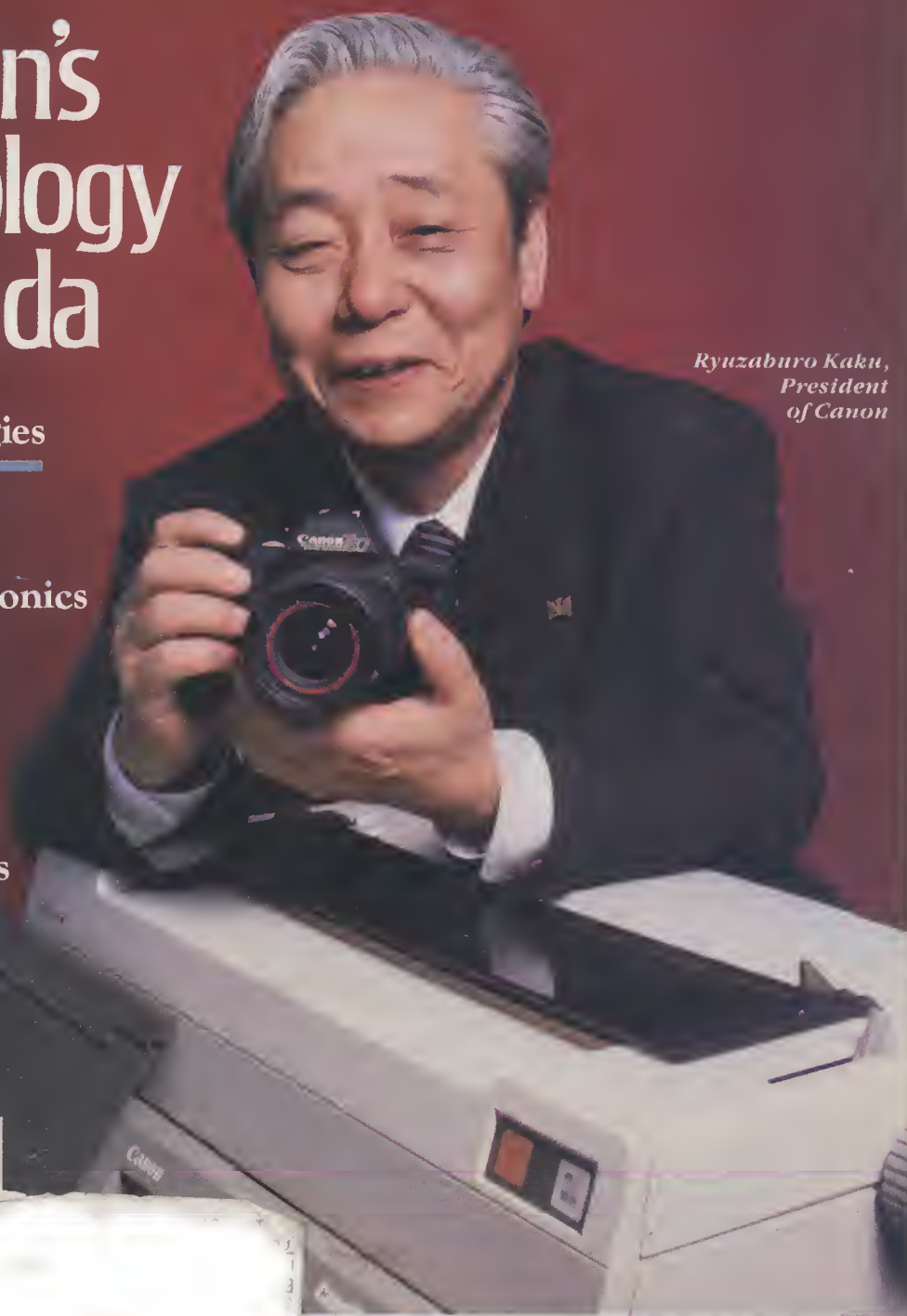
AMERICA'S FASTEST-GROWING BUSINESS

Japan's technology agenda

Industrial strategies

Cameras
Automobiles
Consumer electronics
Semiconductors
Optoelectronics
Biotechnology
Ceramics
Computers
Micro peripherals

*Ryuzaburo Kaku,
President
of Canon*





THE SKY WAS THE LIMIT.

AT&T has shattered the information barrier—with a beam of light.

Recently, AT&T Bell Laboratories set the world record for transmission capacity of a lightwave communications system—20 billion pulses of light per second. The equivalent of 300,000 conversations, sent 42 miles, on a hair-thin fiber of super-transparent glass. But that's really getting ahead of the story.

Actually, the 20-gigabit record is only one of a series of AT&T achievements in the technology of lightwave communications.

But what does that record mean?

The Light Solution To A Heavy Problem

All of us face a major problem in this Information Age: too much data and too little information. The 20-gigabit lightwave record means AT&T is helping to solve the problem.

For data to become useful information, it must first be quickly, accurately and securely moved to a data transmitter—a computer, for instance. Getting there, however, hasn't always been half the fun.

Metallic pathways have a limited transmission speed, sensitivity to electrical interference and potential for interception—factors that reduce the effectiveness of today's powerful computers. Factors that are eliminated by lightwave communications technology.

Ten Goes Into One 20 Billion Times

Three primary components make up any lightwave communications system. On the transmitting end, a laser or light-emitting diode; on the receiving end, a highly sensitive photodetector; and in the middle, super-transparent glass fibers we call lightguides.

Installing these fibers is a major cost of a lightwave communications

system. So, once installed they should stay put—increased capacity should come from fibers carrying more, rather than from more fibers.

Which brings us to the 20-billion bit-per-second story—about experimental technology that has the potential to upgrade installed fiber to meet any foreseeable capacity needs.

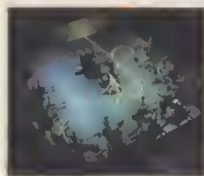
Using new, sophisticated lightwave system components, we multiplexed (combined) the outputs from 10 slightly different colored 2-billion bit-per-second laser beams into a single 20-billion bit-per-second data stream.

Playing Both Ends Against The Middle

But, let's start at the beginning—the 10 distributed feedback laser transmitters.

These powerful semiconductor lasers can be grown to produce light of different, but very precise, wavelengths. The lasers we used transmitted in the 1.55 micron (infrared) range, with only minuscule fractions of a micron between their wavelengths. The purity and stability of the beams let us pack their ten colors into the most efficient transmitting region of our single-mode, silica-core fiber.

To make the original 10 beams into one, a fiber from each laser was fed into a new lightwave multiplexer—a



20-gigabit
multiplexer

prism-like grating that exactly aimed each beam into the single transmission fiber: Over 42 miles later, a second grating fanned the beam back into its original 10 colors for delivery to 10 exceptionally sensitive avalanche photodetectors—receivers that convert the light pulses back into electrical signals and amplify them many times.

A similar avalanche photodetector

was the receiver when AT&T Bell Laboratories set the world record for unboosted lightwave transmission—125 miles at 420 million bits per second.

From Sea To Shining Sea

System capacity is important. But system reliability is vital. Especially when the system is going under 10 thousand miles of water—and is expected to last for 25 years.

AT&T is going to build the first lightwave communications system under the Atlantic Ocean. A similar system is planned for the Pacific. In 1988, laser beams traveling through two pairs of glass fibers will carry the equivalent of 37,800 simultaneous conversations overseas, under-water, from the U.S. to Europe and the Far East.

AT&T has manufactured and installed lightwave systems—as large as the 780-mile Northeast Corridor and as small as single-office local area networks—containing enough fiber to stretch to the moon and back. And the capacity of each network is tailored to meet the unique needs of its users.

Systems being installed in 1985 will be able to grow from 6,000 up to 24,000 simultaneous conversations on a single pair of fibers.

AT&T is meeting today's needs with lightwave systems that are growable, flexible and ultra-reliable. And anticipating tomorrow's needs with a whole spectrum of leading-edge lightwave communications technologies.



AT&T

The right choice.

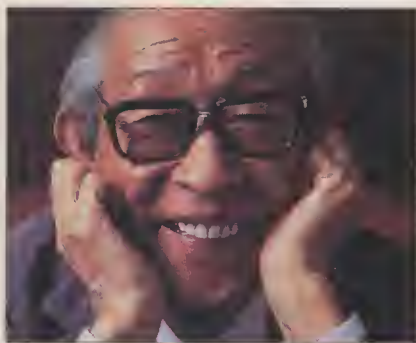
A new technique may expand the use of lasers in commercial and military applications. The approach, called optical phase conjugation, is considered a major advance in optics because it offers a solution to distortion problems that have limited the use of lasers. When a laser beam passes through a turbulent atmosphere or a severely strained optical component, the beam is distorted and the information it carries is degraded. Hughes Aircraft Company's technique, however, forces the laser to retrace its path through the distorting medium so the beam emerges free of distortion. The method eliminates the need for complex electro-optical and mechanical components to correct the distortions.

A future generation of infrared "eyes" for space surveillance systems will be far more capable as the result of technology advances at Hughes. These systems will be able to see distant targets in space, in the air, or on the ground—and relay data instantly to ground stations. Advances are being made in focal plane design, signal processing architecture, and in the design of a unique sensor with very steady telescoping optics. By building modularity and programmability into the new technologies, researchers are making it possible for systems to use tailored combinations from a single family of hardware and software. For its advances, Hughes received an Award for Technical Achievement from the Strategic Technology Office of the Defense Advanced Research Projects Agency. This effort was sponsored by DARPA and monitored by the U.S. Air Force Space Technology Center.

A laser that won't cause blindness or other eye injuries will be used in a rangefinder now under development by Hughes for the U.S. Army. The lightweight device, designated the AN/PVS-6 Mini Eyesafe Laser Infrared Observation Set (MELIOS), resembles a binocular case. Its neodymium yttrium aluminum garnet laser beam is sent through a chamber, or cell, filled with high-pressure methane gas. There the 1.06-micron wavelength is transformed into a wavelength of 1.54 microns. The new signal is safe because it never reaches the retina, but instead is absorbed in the vitreous humor, the white area of the eye between the retina and the lens. MELIOS is being developed under a competitive contract from the U.S. Army Night Vision and Electro-Optics Laboratory.

Large ceramic circuit boards will be built into the Amraam missile to help keep the missile reliable, lightweight, and low in cost. These boards, measuring 5x7 inches, are used instead of standard printed wiring boards where many components must be crammed into a small space and where a lot of heat must be dissipated. The cost of these circuit boards has been lowered significantly by replacing gold circuits with copper. The boards are manufactured by a thick film process in which layers of copper and glass dielectric are alternately applied to provide a multilayer circuit board. Hughes designed and developed the advanced medium-range air-to-air missile for the U.S. Air Force and Navy. The manufacturing facility is located in Tucson, Arizona.

Excellence in communications systems engineering has placed Hughes in a leading position in many of the major U.S. Air Force, Army, Navy, and Marine Corps communications programs, including PLRS, PJH, MILSTAR, and JTIDS. Our Communications Systems Division is committed to meeting the strategic and tactical communications requirements of the 1990s and beyond. We have a continuing need for qualified engineers in all communications systems disciplines at all levels. If your career goals include design of advanced antijam communications systems or HF through millimeter-wave radios, please send your resume to Hughes Ground Systems Group, Professional Employment, P.O. Box 4275, Dept. S2, Fullerton, CA 92634. Equal opportunity employer. U.S. citizenship required.



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Time for partnerships with Japan

Japan has earned its spurs in technology. With limited natural resources and a population half that of the United States concentrated in a land area about the size of California, the Japanese have worked a technological miracle.

And the momentum isn't slowing; it's accelerating. Progress is now being made across a steadily broadening base of advanced technologies while the whole nation retains the contagious excitement and competitive aggressiveness of a technology start-up.

The changes have been so remarkably rapid that conventional attitudes about Japan's place in the industrialized world are mostly obsolete. The stereotype of the Japanese as technology copycats who lack the creativity to innovate has been reduced to nonsense. Consider what's happened in cameras. Japanese craftsmen did master camera design at first by copying others, particularly the Germans. Thereafter, as detailed in the Special Report in this issue, they made important original contributions by bringing point-and-shoot simplicity to the 35mm, making it a family camera. Now, using advanced electronics, they hope to move this technology up to the more complex single-lens reflex. Japanese automakers, already responsible for such advances as stratified charge engines, are working toward other innovations, such as four-wheel steering. Robotic technology is more advanced in Japanese factories than anywhere else in the world.

Charges that Japan does little of its own basic R&D, preferring instead to apply research borrowed from other nations, will also soon be outmoded. This approach may have helped Japan catch up, but now that it has reached the forefront in so many fields there is a national push toward basic research.

The rest of the world must bring its perceptions about Japan into conformity with the new reality. The Japanese are the equals of any nation in many key technologies and are moving steadily ahead in others. They have earned their place in world markets with well-made, useful products. Already, astute business leaders are recognizing the new equation, and are forming partnerships and alliances. A similar working relationship must be worked out at the national level. To fall back on trade barriers will hurt everyone in the long run. The Japanese themselves, now so dependent on exports, will have to make adjustments beyond token gestures to maintain the goodwill of their trading partners. Japan is no longer a land of poverty and struggle. It has become a world leader, with the responsibilities as well as the opportunities of that distinction.

All sides can benefit from global relationships based on mutual friendship and respect. Conversely, all will lose if rifts deepen and trade barriers rise.

Robert Haavind

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 neering at MIT, composites manufacturing
 at Delaware in association with Rutgers's
 ceramics department, robotics for microelec-
 tronics at the University of California (San-
 ta Barbara), telecommunications at Colum-
 bia, intelligent manufacturing systems at
 Purdue, and systems engineering at the Uni-
 versity of Maryland. Information about sub-
 mitting proposals for 1986, due Sept. 3, is
 available from the Engineering Research
 Centers Program, National Science Founda-
 tion, Washington, DC 20550, (202) 357-9707.

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 McDonnell Doug-
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 ("Space station
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 press time for "De-
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 (June 1985, p. 64),
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Robert Haavind

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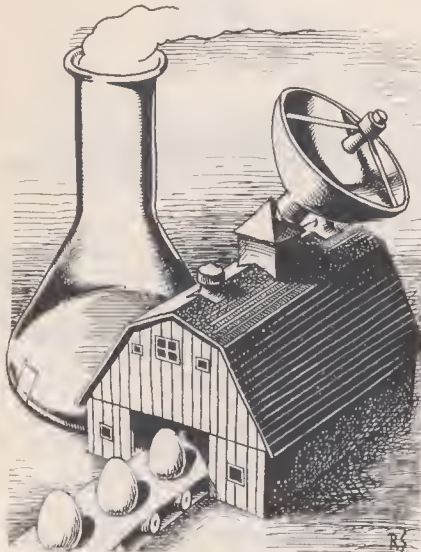
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LETTERS



Bringing technology to business

I support your views on "market-oriented technology centers" (March 1985, p. 4). Illinois has established eight such centers on the campuses of our universities with the mission of applying technology to commercialize products or to improve manufacturing processes for Illinois businesses. In addition, the state is sharing some of the costs and risks of financing these new kinds of ventures by means of the Business Innovation Fund and the Illinois Seed Fund. And we are now working with the four federal research labs in Illinois on a pilot project to encourage commercialization of their work.

James R. Thompson
Governor of Illinois
Springfield, Ill.

Editor's Note: Several other states have programs like that of Illinois, and the National Science Foundation has just funded six new multidisciplinary engineering research centers at universities around the country (chosen from 142 proposals). More new centers will be funded in future years. Each of the six being started in 1985 will concentrate on a specific field: biotechnology process engineering at MIT, composites manufacturing at Delaware in association with Rutgers's ceramics department, robotics for microelectronics at the University of California (Santa Barbara), telecommunications at Columbia, intelligent manufacturing systems at Purdue, and systems engineering at the University of Maryland. Information about submitting proposals for 1986, due Sept. 3, is available from the Engineering Research Centers Program, National Science Foundation, Washington, DC 20550, (202) 357-9707.

Preserving the environment

I'm offering a mild objection to your sub-head "Saline farmland may be reclaimed by tailoring plants to suit the environment" ("Helping crops stand up to salt," May 1985, p. 66).

In agriculture, *reclaim* generally means to prepare for cultivation or to restore to fertility. Breeding and genetic engineering of plants to suit them to salt-poisoned soil is very different from preventing or reversing soil salinity problems. Although salt-poisoned land may be utilized for the cultivation of natural or developed salt-resistant plants, that doesn't restore the soil's normal fertility.

We humans are very clever, but we'd be wiser to maintain a clean environment instead of creating salty desert conditions on some of our most important crop lands, and then trying to develop salt-tolerant life forms.

Terry Ehrlich, Publisher
Hemmings Motor News
Bennington, Vt.

A hand for machine tools

You are to be complimented on your article "Helping machine tools help themselves" (June 1985, p. 44). It discussed the complex subject of untended machining clearly and logically. Franz Herko, the Kennametal scientist quoted in the report, was pleased with its depth and accuracy.

Bill Kennedy, Manager
Product Publicity
Kennametal
Latrobe, Pa.

Airborne laser a victim of bad press?

As a member of the Air Force's Airborne Laser Laboratory project for many years, I have become disgruntled at constantly seeing it referred to as "having failed miserably during a public test firing in 1981" ("Laser weapons come down to earth," May 1985, p. 69). The test in 1981 was not meant to be "public," although it became so. It was a feasibility study and data-gathering mission that received extremely bad press, although its results helped immeasurably in determining the corrective action required to perform successful missions two years later.

The project, still the only working system of its kind, was canceled, rendering useless the integrated aircraft systems and all the support facilities built specifically for it. I only hope that the database that was gathered is not lost in the shuffle, forcing the wheel to be reinvented on any future project.

Ernest G. Endes
Sperry Corp.
Albuquerque, N.M.

Wind turbines

I would like to make some comments on the Update article "Wind turbine exploits Venturi effect" (June 1985, p. 9). First, the wings of the Venturi Rotor Wind Energy Converter rotate, but not around the central spoiler core. The entire device rotates about its central axis.

Second, the pressure drop is behind the airfoils, creating a net positive force in front of them. This force acts about the central axis.

Third, the article states that the Venturi Rotor will sell for "three times the cost of a propeller turbine of equivalent size." In fact, the Venturi Rotor costs approximately a third less than a propeller-type machine with the same output. We can also operate over the full range of wind speeds (6-160 mph).

Fourth, you quote a wind-energy consultant who doubts that the Venturi Rotor would be economical at wind speeds below 40 mph. We calculate that an average annual wind speed of 18 mph will achieve a cost threshold of 4¢ per kilowatt, competitive with new hydrodams.

Donald L. Stone, President
Herrmann Rotor Company
Chicago, Ill.



Corrections: Pictured is the real Robert F. Thompson, VP of space station programs at McDonnell Douglas Astronautics ("Space station contractors," April 1985, p. 18). At press time for "Defend your data!" (June 1985, p. 64), the Backup software package was available from Infotools for \$150. Infotools has since been acquired by Software Integration (Los Angeles), and the price is now \$180.

UPDATE

Aircraft makers eye advanced engine

A new type of fuel-efficient jet aircraft engine being developed by GE (Cincinnati) has caught the attention of major air transport makers. Boeing Aircraft (Seattle) and McDonnell Douglas (St. Louis), the nation's first and second largest makers of commercial and military air transports, recently revealed that they are considering the engine for their next generation of transports. GE's "unducted fan" (UDF) is similar to current jet transport engines in that it uses a turbine-driven fan (essentially a small propeller) to supply thrust. But the engine's fan, which consists of two counter-rotating sets of blades, is much bigger (too big to be encased in the engine's air duct). The result is greater thrust and therefore better fuel efficiency.

Ground tests indicate that the new engine would offer efficiency gains of up to 60% over current turbofans and 25% over advanced turbofans now under development. Both Boeing and McDonnell Douglas plan to verify this performance in the air. Boeing will begin testing the engine next year on a 727, and McDonnell Douglas will start in 1987, using an MD-80 airliner. According to a GE spokesperson, the UDF could see commercial use by the 1990s.

Cancer therapy market heats up

A new line of hyperthermia (high-temperature) cancer therapy equipment is expected to gain FDA marketing approval soon. Clini-Therm (Dallas) is preparing to commercialize a microwave de-



Wind-tunnel model of a McDonnell Douglas MD-80 airliner demonstrates GE's fuel-efficient unducted fan engine.

vice now used in research at 36 U.S. sites.

Hyperthermia (of which there are several types) is usually combined with other cancer therapies, such as x-radiation. In the Clini-Therm model, microwaves are aimed at a tumor lying on or near the skin surface, as in breast cancer. The waves heat the tumor's innermost cells, which are not easily reached by x-rays, to about 110° F; radiation therapy is then used to attack the cells lying closer to the tumor's surface. An immediate benefit is that patients receive a lower dose of radiation, so they suffer fewer of its side effects. In many cases, the dual treatment is claimed to double the effectiveness of radiation alone.

BSD Medical (Salt Lake City), until now the sole supplier of hyperthermia equipment, introduced its devices in 1978, and last year received FDA approval for two types. The firm will soon seek approval of another device, this one for treating deep-body tumors.

Once shrouded in controversy, hyperthermia has apparently won support by a large number of researchers for treating certain cancers. Moreover, it was recently cited as a reimbursable therapy by Medicare and other insurance providers. The result, says a BSD spokesperson, is a growing list of small companies readying devices for FDA approval and marketing.

West Germany links cities with fiber optics

The West German Postal Service has begun testing a broadband fiber optic communications link between Hamburg and Hannover that will transmit telephone conversations, computer data, and video information. This link is the first phase of a planned nationwide communications network called BIGFON (a German acronym for broadband integrated fiber optic long-distance network). By the end of the century, BIGFON will connect seven major cities: Hamburg, Hannover, Düsseldorf, Stuttgart, Nuremberg, Munich, and West Berlin. The system employs technology similar to that of other experimental broadband networks being tested in France, Japan, and Canada.

The recently completed Hamburg-Hannover link consists of 160 kilometers of optical cable containing 60 graded-index, multi-mode glass fibers. Eight repeater stations spaced at 18-km intervals amplify the light pulses. With a data rate of 140 megabits per second, the cable has enough capacity for two long-distance telephone and data channels, 2-4 TV channels, 24 stereo radio channels, and a bidirectional videotelephone channel with color capability. Initial testing, to last through 1986, involves some 320 households, 64 of them equipped with videotelephone terminals.

UPDATE

Vehicle navigation system takes care of business

An on-board navigation system being tested by Japanese automaker Nissan not only keeps commercial vehicles on course but also plans delivery routes and processes orders. In the test, a delivery van is equipped with a micro-computer and a special radio receiver. The driver inserts a floppy disk with the day's deliveries and other customer data into the computer, which then calculates the delivery sequence and shows the appropriate map on a color video screen. The driver, whose location is constantly displayed on the screen, simply follows the route indicated. When a package is delivered, the driver checks it off on the screen using a lightpen. The system can also handle payments and additional orders.

The van's position is determined with loran (*long-range navigation*) C, a technique involving pairs of ground-based radio transmitters and used around the world by ships and aircraft. Nissan has developed a sensitive receiver capable of picking up loran signals on land, where they are weaker and often subject to noise. The system can determine the van's position to within about 500 feet. Nissan expects eventually to use signals from the Global Positioning System (GPS) satellites now being orbited. This should improve accuracy to within 100 feet.

The experimental system costs around \$8000 to build, making it uneconomical for use in personal cars at this stage. However, Nissan describes the test as one step along the way to a "mobile information office for both passenger cars and commercial vehicles."



Nissan's navigation system displays delivery routes.

Software links different mainframes

A software package being developed by Software Research Corp. (Natick, Mass.) will enable two mainframe computers of different makes to exchange information via data communications networks conforming to IBM's Systems Network Architecture (SNA) standard. Running on both machines, the package will establish a link between them and translate information from the format used by one into the format used by the other. Initially it will support IBM, Burroughs, and Digital Equipment Corp. computers, with other machines to be added later.

The new package is intended to fill a significant gap in the market, according to Alan Vecchio, VP of engineering and a co-founder of Software Research. IBM currently offers a software package called the SNA Distribution System (SNADS), which enables computers of different types to exchange information via SNA networks. However, SNADS supports only IBM machines. A few independent software firms offer packages that enable non-IBM computers to exchange information via an SNA network, says Vecchio, but those packages are based on various IBM network operating programs. In contrast, the SRC package is self-contained and hence will not be affected by any changes IBM may make in its operating software. Developed over the last three years at a cost of

some \$5 million, it should be introduced later this year.

Jump-starting a satellite

NASA is quickly establishing itself as the world's first and only in-space satellite salvage and repair service. In the last year, Space Shuttle crewmembers revived a moribund scientific satellite (Solar Max) in space and brought two errant communications satellites (Western Union's Westar and Indonesia's Palapas-B) back to earth for repair. This month a shuttle crew is slated to fix another communications satellite, the \$80 million Leasat 3. Its on-board orbital transfer engine failed to ignite after a successful launch into low earth orbit from the shuttle in April. As a result, the satellite never reached its intended geosynchronous orbit 22,300 miles above the earth. Hughes Aircraft (Los Angeles), developer and owner of the satellite, traced the problem to a failed rocket ignition sequencer aboard the satellite. In the upcoming rescue attempt, NASA astronauts will attempt to "hot-wire" a new radio command system to the satellite, thus bypassing the failed sequencer. The repair mission should cost far less than the \$10 million spent to retrieve Westar and Palapas-B, says a company official. And if successful, it could save Hughes some \$50 million in ground-based refurbishment and relaunch costs.

A close-up photograph of a hand holding a large metal key against a dark blue background. The hand is positioned on the left side of the frame, with the thumb and index finger gripping the handle of the key. The key itself is a large, industrial-style key with a complex, multi-toothed profile. The lighting is dramatic, highlighting the metallic texture of the key and the skin of the hand. The background is a solid, deep blue.

Coordination unlocks

If you're like many manufacturers, you automate work centers one at a time, as the need arises.

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Computers and communications: toward peace and prosperity

by Koji Kobayashi
Chairman of the Board and Chief Executive Officer
NEC Corporation

Throughout my 56-year career at NEC, I have dreamed of the day when anyone could talk to anyone else—anywhere in the world—at any time. My dream has come about because understanding between nations is so terribly inadequate; I am convinced that the free exchange of ideas between peoples of different countries, assisted by advanced technology, could contribute greatly to world peace.

Consider, for example, an automatic interpretation telephone system. If the caller were speaking to me, say, in English, his words would be electronically translated and I'd hear them in my own language. I could answer in Japanese, and he'd hear me in English. The system would not only make daily business extremely convenient but also improve international relations enormously. The barriers of language would be removed. People throughout the world, at the grass-roots level, would be able to communicate as never before in history and could better appreciate each other's lifestyles and ways of thinking. We could be reminded daily that we are all fellow members of the human race.

NEC demonstrated a rudimentary version of such a system a couple of years ago at the Telcom 83 exhibition in Geneva, Switzerland. It attracted a great deal of attention, but it was just a research model capable of only a limited vocabulary and sentence structure. We are continuing extensive research into more sophisticated machine translation and voice recognition technologies, however, and if progress continues as expected, we could well be able to realize a commercial model by the year 2000.

The automatic interpretation system is a relatively long-term goal; but it is part of a phenomenon that is very much here-and-now. The integration

of computers and communications, which I like to call C&C, is promoting a transition toward a sophisticated "information society" and redrawing the industrial map of the world. At NEC, which has been in the telecommunications business since its establishment 86 years ago and in the computer and semiconductor businesses for some 30 years, we have been able to perceive and respond to this major market shift. I'd even go so far as to say that our corporate mission is to solve problems and create business opportunities through C&C.

*Advancement in
software technology
is needed far more
than in hardware.*

We are not alone, however. As we observe the recent moves of giant American corporations, we see the leader in communications, AT&T, penetrating the field of data processing, while IBM, the leader in computers, is entering the communications field. In France, C&C is a major national priority that is called *télématique*. But although expressions may differ, it is clear that the whole world is rushing to integrate computers and communications. I consider this digitalization of communications to be one of the central trends in electronics for the rest of this century, and I am confident that C&C will continue to progress well into the next.

The result will be a global informa-

tion infrastructure—a network of businesses devoted to knowledge, information, and the equipment for handling them. The development of such C&C systems will steadily reduce the cost of disseminating information even while the value of that information rises. Thus an enormous volume of information will virtually be free to flow internationally. And this will bring about a truly information-oriented global society.

Because it is difficult to uncouple material flow from geographic, time, and resource restrictions, a society that has grown only through its heavy industries will sooner or later reach its limits. And developing countries may take a long time to reach maturity. But because information flow, thanks to C&C, is rapidly being freed from such constraints, the prospects for information-based economies seem tremendous.

Consider, for example, the modern manufacturing plant. In order to respond to the shift from mass-orientation toward product diversity and individuality, and to meet a wider variety of customer needs, very large amounts of information will have to be generated. The transfer and processing of this information, moreover, will be done at the plant. And if sudden changes in the market occur, it will be necessary to rapidly adjust the design and manufacture of products accordingly. But for all this to occur, the flow of information at all levels, from the plant floor to the customer, will have to be coordinated. C&C technology has already begun to be the basis of such manufacturing—and as it evolves, the sophistication of manufacturing will also grow.

It will be essential that such production systems be "distributed"—that they be close to their markets—and

INSIGHTS

that information-processing systems, both technical and administrative, be decentralized as well. Such systems will have to be "intelligent" and "friendly" in order to accommodate a wide variety of users so that broad participation in the manufacturing process, and the quality of its products, is assured. At this stage, therefore, great advances in the technology of information processing are far more necessary than improvements in production technology.

I would note that the point of introducing leading-edge technologies is not to exclude human beings but to center these systems around them in order to make the best use of human creativity and flexibility. I do not know of a single example where it has become possible to completely eliminate human beings from the production process. This is because humans alone have the ability to improve production and cope with uncertainty.

whether C&C can produce desirable benefits for humanity depends on the rationalization of software production.

In modern manufacturing, the flow of information at all levels, from the plant floor to the customer, will have to be coordinated.

At present, when human beings use communications, it is their performance that is improved.

forced to learn the language of the machine, in effect, rather than vice versa. Gradual improvements in programming languages are being made, of course, and the amount of labor required by the user has been steadily diminishing. But no machine is user-friendly enough as yet. The ideal we are striving for is to make it possible for anyone, not just an expert, to fully and easily utilize information systems and obtain the greatest economic, social, and cultural benefits from C&C.

Thus advancement in software technology is needed far more than in hardware. Without profound progress in software-production technology in particular, it will not be possible to develop advanced manufacturing systems and respond to their diversified needs. But I have great confidence in our ability to achieve that progress. And I am confident that my dream of effortless global communication, with its contribution to world peace, will be realized. □

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INTEGRATION

ACCESSIBLE CONTROL IN THE PLANNED ECONOMY: PATHWAYS TO A TRULY INFORMATION-ORIENTED SOCIETY

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BUSINESS STRATEGIES

Tektronix:

BRINGING UP A GaAs BABY

Much to its chagrin, Tektronix has been the breeding ground for many a successful high tech start-up. Weary of watching its best talent leave to form such hits as Mentor Graphics and Metheus (both makers of engineering workstations), the Beaverton, Ore., maker of test and measurement equipment decided to get in on the entrepreneurial action. In 1983, it formed its own venture capital subsidiary, Tektronix Development Corp. (TDC).

The latest TDC protégé—a maker of gallium arsenide (GaAs) integrated circuits—is TriQuint Semiconductor (Beaverton, Ore.), the spinoff of a division Tek established to develop GaAs chips for internal consumption. GaAs circuits operate far faster than their silicon counterparts because electrons travel through GaAs more easily than through silicon, and GaAs chips can withstand doses of radiation that would render a silicon device helpless. But gallium is a rare and expensive metallic element, and GaAs crystals are both brittle and difficult to produce free of impurities. Even though many companies and the government's Defense Advanced Research Projects Agency (DARPA) have poured millions into improving production techniques, GaAs chips are 10 to 15 times more expensive to produce than silicon chips.

Tek soon discovered that making GaAs chips was too expensive for its own limited needs. But it also realized that the outside market for GaAs devices might soon be taking off; market research firm In-Stat (Phoenix) currently predicts that the worldwide market for GaAs components will soar from \$92 million this year to over \$2 billion by 1990. Although the decision to form a new company was inevitable, says TriQuint president Alan D. Patz, Tek first staged a market test—a luxury unavailable to most start-ups. It began selling GaAs chips to the public in October 1984. When the market responded favorably, says Patz, the spinoff plan started rolling.

Tek won't disclose the amount of its investment, but TriQuint market-

ing manager Thomas Reeder says that the sum was "average" for a capital-intensive venture. (Fellow GaAs start-up Anadigics of Morristown, N.J., for example, just completed an \$8 million first round of venture financing, bringing its total equity to \$13 million.) Reeder also says that TriQuint is soliciting support from another large corporation that uses GaAs chips, but adds that Tek intends to maintain a controlling interest.

TriQuint's current products are all small-scale, specialized integrated circuits, split half-and-half between digital chips (used for signal and data processing) and analog microwave components (used in instruments such as Tek oscilloscopes). But the company plans within 18 months to start selling standard analog components used widely in telecommunications gear. Longer-term projects include large-scale integrated circuits and random-access memory devices.

Having a parent with \$1 billion in annual revenues is a big plus for TriQuint. But the young company faces stiff competition. William Grove, editor of the In-Stat Research Letter, places TriQuint fourth—behind Harris, Honeywell, and GigaBit Logic—in GaAs chip sales. Both Harris and Honeywell surpass TriQuint's parent in overall sales. And even though GigaBit is a start-up (backed by General Electric Venture Capital), it has already forged connections with important customers. Supercomputer leader Cray Research, for example, will use GigaBit chips in its next generation of powerful computers.

Tek itself is a valued customer for TriQuint, but Patz predicts that the parent company will never account for more than 10% of overall business. Of TriQuint's 20 current customers at the chip design or fabrication stage, 40% come from military and aerospace industries and 60% from the commercial sector. But the company's production volume has a slightly different split; at 20% aerospace/military and 80% commercial, it reflects an industrywide trend away from today's market dominance by aerospace/military custom-



TriQuint's Alan D. Patz expects the firm to produce 90% of its chips for the open market and only 10% for its parent firm, Tektronix.

ers. Market research firm Strategic Inc. (Cupertino, Cal.) predicts that because of the larger manufacturing volumes of commercial products, commercial sales of GaAs chips will eventually outnumber military sales four to one.—Anne Knowles

Olin:

CHEMICAL GIANT LEAPS INTO ELECTRONICS

In its attempt to enter the electronics industry through the acquisition of small, "second-tier" companies, Olin (Stamford, Conn.) is taking a well-worn path. "Olin is one of several giant chemical companies with designs on the electronics industry," says industry consultant and researcher Daniel Rose, mentioning such examples as W. R. Grace and Rohm & Haas. But unlike other companies, which seem to bid on every small electronics firm that comes up for sale, he says, "Olin appears to have thought out a complete strategy." Thomas Berardino, senior VP of corporate planning and development and also president of the new electronics materials and services group, says, "We aren't going to buy a lot of little companies and let them all run themselves. We're building a total capability in electronics."

COPYING ENTERS THE LASER AGE.

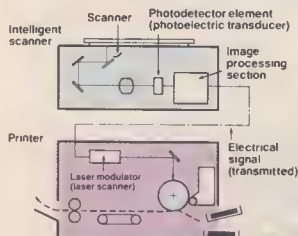
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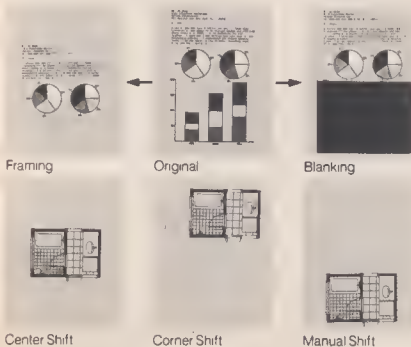
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Assuring you of high quality copies every time.

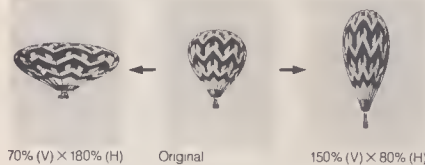
Imagine the possibilities as the Laser Copier lets you create new images.

Because the NP-9030 is a copier with intelligent functions, it can modify the images of the original by carrying out the most sophisticated editing assignments based on your individual commands.



The NP-9030's editing functions include **Framing**—for copying individual parts of the original image; **Blanking**—for deleting parts of the original and **Shifting**—to move

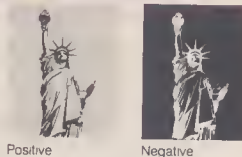
an image to any desired position on the copy. With **Vertical/Horizontal Reproduction Ratio Control**, the copier can inde-



pendently reduce or enlarge the vertical or horizontal segment of an image from 50% to 200% in 1% increments.



The **Positive/Negative** function can even reverse black images to white and white images to black.



And the **Multi-Program Memory** lets you preset up to 12 sets of your most frequently used copying instructions for easy access.

Digital technology gives you automatic convenience you've never had before.

With **Automatic Original Recognition**, because the copier automatically recognizes the size and position of the original, it facilitates **Automatic Paper Selection** for correct paper sizes and **Automatic Reproduction Ratio** for setting the zoom.

In addition, the NP-9030 has **Automatic Exposure** and **Automatic Two-Page Separation**.

Standard features on the Laser Copier System are anything but ordinary.

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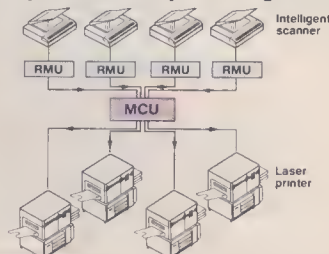
Wide Zoom Range: 50% to 200%.

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Olin wants to forge recent acquisitions into a unified group that supplies the electronics industry, says senior VP Thomas Berardino.

Olin, which earned \$88.7 million on \$2.06 billion in sales last year, started its push into the electronics industry in 1982. Although the company had long been selling high-performance alloys (made by its Olin Brass group) for use in the production of printed circuits and related electronics applications, it was the astounding market growth spurred by advances in microchip technology that caused Olin to take its electronics business segment more seriously. Corporate management charged Berardino with shaping a new electronics group, which it designated one of the company's three core growth areas.

The first major step came with the December 1982 purchase of nearly two-thirds of Philip A. Hunt Chemical Corp., a supplier of chemicals used in manufacturing semiconductors and printed circuit boards. (Olin acquired the rest of Hunt in 1984, bringing the total cost to \$130 million.) Hunt supplies photoresistive chemicals for etching circuit patterns on silicon wafers and liquid and dry toners for copy equipment, and it has a division that makes printed circuit etching equipment. Hunt gave Olin a presence in

electronics chemicals that complemented its existing metals business, says Berardino. It also gave the new electronics group the "critical mass to support a continuing effort in R&D and sales," he explains. "Once we had that base, we could afford to go out and buy some smaller pieces or do more internal development."

Since the Hunt deal, Berardino has been hot on the acquisitions trail. On the chemical side, Olin purchased Hi-Pure Chemicals, a semiconductor acid and solvent maker, from Allied Corp.; Apache Chemicals, a semiconductor dopant maker; Mesa Technology, a maker of bonding material for semiconductor packaging; and 45% of Indy Electronics, a semiconductor packaging contractor. Olin also recently funded Matrix Integrated Systems, a start-up company that will function as a wholly owned subsidiary, to develop a new semiconductor etching technology.

On the metals side, Olin signed a deal to purchase technology and equipment from W. C. Heraeus of West Germany for making specialty cladding and inlay materials for electronics. And Olin has made acquisitions and investments in other new technologies such as fiber optics. In 1984, Olin's electronic materials and services business generated more than \$150 million in sales, up from 1983's \$60 million.

The challenge is to forge these disparate organizations into one chemical/metal entity. But progress seems well underway. Mesa Technology, for example, uses Hunt photoresistive chemicals and Olin copper alloys to produce a tape material for its tape-automated bonding technique. And Indy Electronics uses Mesa products to bond semiconductors to their ceramic packages. Fitting the organization's pieces together will depend on the skill and vision of management, says consultant Rose. But so far, he says, "Berardino has done a splendid job." Despite the severity of the recession in microelectronics, Olin is continuing to expand. Rather than pulling back in panic, says Rose, Olin is "looking at the long term."—Mark Mehler

Internet:

CASHING IN ON INTERNATIONAL BANKING NEEDS

Bankers' hours aren't what they used to be. No longer do banks open at 9 a.m. and close five or six hours later. Today, international banks have offices around the globe and stay "open" 24 hours a day, every day. Widely fluctuating exchange and interest rates, the advent of the Euro-dollar, and financial instability caused by spiraling national debts have all contributed to dramatic changes in international banking. To stay competitive, multinational banks must adopt procedures and technologies that let them transcend distance and time zones.

But many international banks, using software developed in the '70s, have to shut down their computers for several hours every night to process financial data entered earlier in the day. This "batch" processing can delay an accurate account status for 12 hours, limiting a bank's ability to monitor worldwide business transactions and take advantage of currency fluctuations. However, a new generation of software—transaction processing—can update databases continually in "real time," eliminating delayed information and making a daily shutdown unnecessary. Three-year-old Internet Systems (Chicago) has used this technology to develop 14 integrated software modules that handle an international bank's computing and telecommunications needs, both within separate branches and throughout a global network. The modules include foreign exchange, loans and deposits, commercial credit, and funds transfers, and they coordinate communication over specialized banking and public telecommunication networks.

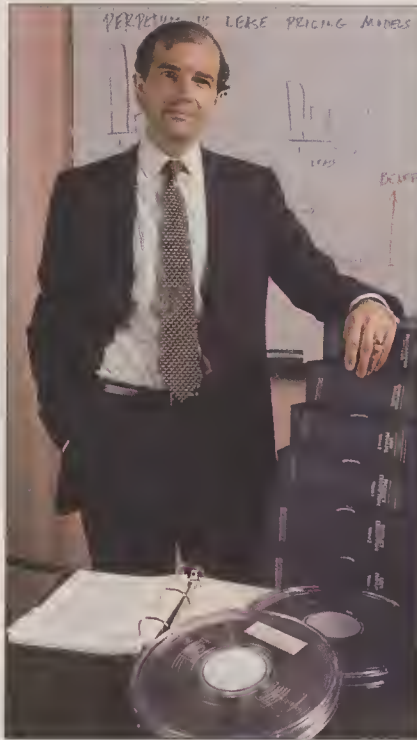
Traditionally, multinational banks have developed their own software. In fact, Internet's founders come from the First National Bank of Chicago, where they developed an earlier international banking system. But soaring development costs and shrinking software life cycles have forced even the biggest banks to turn with increasing frequency to independent software ven-

dors. That's what convinced Internet's founders to strike out on their own—and what convinced backers (including Kleiner Perkins Caulfield & Byers, Hambrecht & Quist, Morgan Stanley, Abingworth, GT Capital, Sofinnova Ventures, La Compagnie Financiere, and Mirabaud & Co.) to provide \$8 million in venture capital.

Most international banking software consists of single-application systems. But Internet's system is modular, letting customers install individual programs and later expand to include others. The system's hardware—multiprocessor minicomputers from Tandem Computers—is also modular, providing additional flexibility. For example, "a relatively small bank branch can install a two- or three-processor system linked to the headquarters' 16-processor system," says Victor B. De Souza, Internet's VP of marketing.

The Tandem hardware is also "fault-tolerant" (with architecture and redundant hardware designed for non-stop operation), and it has advanced communications features that let geographically distant branches share data. Some observers are skeptical about the likelihood that banks—collectively among the most loyal IBM customers—will buy another vendor's computers, but Internet is hoping that the Tandem system's features and its ability to communicate with IBM machines will win converts. (Tandem's fault tolerance may not be a distinguishing factor for long; IBM recently made an agreement with Stratus Computer to remarket the Massachusetts company's line of fault-tolerant machines.)

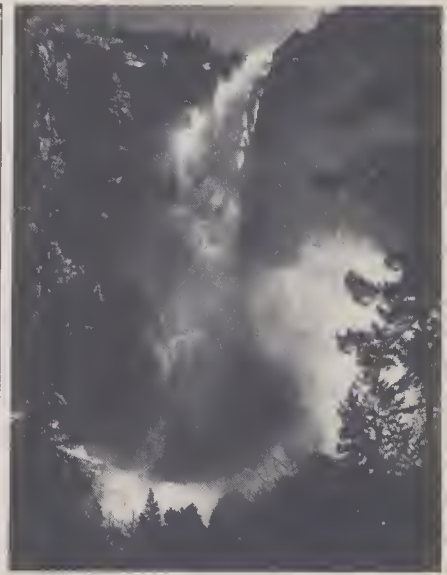
According to Internet president Paul Rachal, his company is targeting "the top 500 international banks." However, the company's immediate targets are the nine large international banks that are members of its own advisory board. In an unusual marketing strategy, Internet convinced the nine to pay a \$40,000 fee and act as consultants in exchange for software documentation, a \$100,000 discount on their first purchase, and the opportunity to influence the product's design. "The board provides guidance to Internet's system designers, telling them what functions banks need to stay competitive," says Rachal. Four mem-



Internet's banking software will help international banks react quickly to fluctuating exchange and interest rates, says president Paul Rachal.

bers—the Royal Bank of Canada, the Bank of Nova Scotia, the Deutsche Bank, and the Nederlandsche Middenstandsbank—have placed orders already. Internet won't say how much they are paying, except that a "typical" first order is \$1.5–2 million.

Surprisingly, Internet has little competition in the potentially sizable market segment for international banking software. Henco Research, a recently acquired subsidiary of domestic banking software supplier Hogan Systems, had been developing a software product line for international banking. But after Hogan suffered a multimillion dollar loss in 1984, it chose to discontinue development. "The Hogan/Henco combination could have been powerful," says Stephen Balog, an analyst with Prudential Bache. "It's not clear sailing for Internet, but this certainly clears the major obstacle." Another potential competitor is Management Technology—itsself a start-up. But with its financing still incomplete as of this writing, the new entrant will be playing catch-up.—*H. Paris Burstyn*



Bridalveil Fall, Yosemite National Park, California c. 1927. Photography by Ansel Adams. Courtesy of the Ansel Adams Publishing Rights Trust. All rights reserved.

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"VAX IS GIVING AMF MORE TIME FOR THE THINGS THAT REALLY MATTER."



Michael Lilly
Director, Corporate MIS/Operations
AMF, Incorporated

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As Michael Lilly says, the company's decision to stake its future in MIS on Digital's VAX computers – and the office automation tools like ALL-IN-1™, DECnet™ and DECmail™ software that run on them – was hardly a snap judgment.

Every major computer company was considered. Lilly says that, "dollar for dollar," only Digital's VAX system offered the power, ease of use and communications capability with other computer systems – including IBM – that AMF needed.

So AMF chose the VAX com-

puter – the best-selling 32-bit computer in the world – and waited to see what the machine could do.

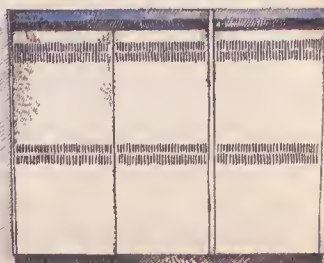
**"SUDDENLY
WE HAVE TOOLS AND
CAPABILITIES WE
NEVER HAD BEFORE."**

Lilly and his group didn't have to wait long. The system was up and running within days.

Reaction within the department was rapid and gratifying. "We really got excited about it," says Lilly. "Immediately, we were communicating better." And there was more – spreadsheets and word processing and a mail system. "Suddenly," Lilly said, "we had a vehicle for total open communications to every impor-

tant person or department in the corporation."

Part of the story behind AMF's almost instantaneous rapport with the VAX system is that it's so easy to use. Menus and operating commands are the same for each fully integrated application. Whole functions are completed in as few as two key-strokes. And because everything is in plain English, it's literally as simple as A-B-C to incorporate





any VMS™ application into the daily work routine.

"INSTEAD OF SIX WEEKS TO DEVELOP AN APPLICATION, IT TAKES TWO."

VMS software development tools have so improved the way things are done in his department, Lilly says, that he projects the savings in applications development time and costs alone at some 70 percent.

"Many of our new applications here at AMF will be written on that machine. I can't quantify it exactly. All I know is that I'm getting a heck of a lot more bang for my buck."

The first tests of VAX equipment proved so successful, that AMF quickly enlarged the system, adding terminals and DECmate™ and Rainbow™ personal computers. New departments went on line, for example finance.

"And that," says Lilly, "really created an explosion." Now AMF is implementing programs like general ledger systems, stock options and inventory sys-

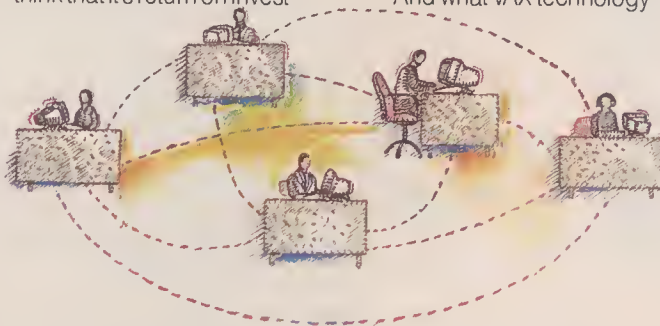
tems, and keeping more efficient and flexible records, from accounts payable to personnel.

Adds Lilly, "People here are screaming to be on the VAX system, and there's got to be a reason for that. And I tend to think that it's return on invest-

department to the forefront.

"It's put corporate MIS on the map," he says. "It has effectively increased productivity and efficiency. People are beginning to believe we can do the things we say we are going to do."

And what VAX technology



ment, mailing lists, discounted cash flows, spreadsheets they couldn't even begin to do before, versatility, tremendous graphics potential. It's just a whole world of opportunity that is elevating AMF to the forefront."

"ANYONE WHO USES VAX IS GOING TO GET THE COMPETITIVE EDGE."

Lilly feels the VAX system has already elevated his own

is doing for his group, Lilly believes, it can do for all of AMF, or indeed for any company. "Any corporation that employs this technology," he says, "is going to get the competitive edge."

"This technology will explode. Because there are a thousand reasons to have it. But what it really all boils down to is this: everybody will want a VAX system because they can do the job better, faster and more efficiently.

"And that's what really matters."

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May 23, 1985

SPECIAL REPORT

JAPAN'S TECHNOLOGY AGENDA



Industry leaders such as Hitachi president Katsushige Mita (far left), Mitsubishi president Yohei Mimura (left), and Matsushita founder and ex-chairman Konosuke Matsushita (below) have helped engineer Japan's successes.



Over the past two decades, Japan has established itself as a front-runner in a wide variety of technology-based markets. Japanese leaders have forged sophisticated industrial policies that balance competition and cooperation, yielding a steady stream of commercially successful innovations.

What's next for this resourceful nation? Several of our editors traveled through Japan,

visiting companies in specific industries to get a firsthand look, while others complemented these efforts with research at home. The result is the following ten-part report. It consists of an overview that analyzes how Japanese government and business work together to develop targeted technologies, and nine articles on Japan's major industries—where they're headed, and how they intend to get there.

Managing the industrial miracle

Forty years ago, at the end of World War II, Japan's economy was in ruins, its major cities lay buried in rubble, its territory was occupied by foreign troops, and its empire was dismembered. Yet in less than four decades, this overcrowded island nation—smaller than California and dependent on imports for 99.8% of its oil, half of its food, and most of its raw materials—has risen from the ashes to become one of the world's great manufacturing powers. By the mid-1960s, Japan ranked third in GNP, and it recently moved into second place, ahead of the Soviet Union. In international trade, Japan's success has been so great that it is sparking protectionist sentiments in the U.S. and Europe.

Conventional wisdom has long attributed the Japanese economic miracle to a monolithic government/industrial complex dubbed Japan, Inc. But although the state has a long tradition of intervening in almost every facet of the economy, most analysts now agree that Japan's industrial success has resulted from a unique blend of cultural, historical, economic, and social factors, in which government policy has played a significant but not dominant role.

Contrary to the notion of "state-run capitalism," Japan's industrial policy recognizes the market as the primary agent of economic activity. The government does not intervene in the management of individual firms, nor has it nationalized industries in financial straits. Instead, the state catalyzes economic growth by supplementing and complementing market forces. It anticipates major developments that will affect the nation's economy and encourages the private sector to make the necessary adjustments as smoothly as possible. "Japan offers an alternative vision of economic planning," writes Robert S. Ozaki, professor of economics at California State University (Hayward). "It is a case of programming for dynamic growth of a competitive economy; planning is thus an instrument of pragmatism devoid of socialist ideological content."

The lead agency in the formulation and implementation of Japanese industrial policy is the Ministry of International Trade and Industry (MITI), which was reformed in 1948 from the wartime Munitions Ministry to direct the recon-

struction of Japan's war-ravaged economy. In addition to making industrial policy, MITI manages Japan's foreign trade and commercial relations, runs the patent office, and ensures that industry obtains an adequate supply of energy and raw materials.

Despite MITI's influence and prestige, it is relatively small, with about 2500 bureaucrats in its central Tokyo office. The majority of the ministry's staff are not technical specialists but well-trained civil servants with a solid grasp of the international marketplace and the leading individuals within each industry. MITI's financial resources are also surprisingly limited; in fiscal 1983 it received only 1.6% of the government budget and spent a total of \$260 million on R&D.

Industry first. MITI's role has changed markedly over the years in response to the shifting realities of Japan's economy and trade relations. Immediately after the war, MITI undertook the enormous task of reconstructing Japan's economy. The ministry implemented an "industry-first" strategy in which well over half the government budget was funneled into industrial development at the expense of other programs. MITI allocated preferred loans and official guidance to a few key industries, including steel, automobiles, shipbuilding, and petrochemicals.

Since most Japanese industries were too weak to hold their own against foreign competition, MITI protected the domestic market with such measures as high tariffs, quotas, and investment controls. These trade barriers would ordinarily have reduced competitive pressures, slowing technological development. But the traditional rivalry among Japanese firms for shares of the domestic market kept most industries efficient and innovative. MITI further stimulated domestic competition by providing incentives and subsidies to entire targeted industries rather than individual firms. When Japanese industry had become strong enough to compete internationally, MITI gradually reduced trade barriers and opened up the economy to world markets. Japan soon became an export-led economy, selling manufactured goods abroad to pay for its vital imports of food, energy, and raw materials. Throughout the 1960s, the Japanese economy grew at the remarkable rate of 10% a year in real terms.

Scholars are divided over the importance of MITI's industrial policy in working Japan's postwar economic miracle. Chalmers Johnson, professor of political science at the University of California (Berkeley), views MITI as the activist hub of the "developmental state." But other analysts argue that MITI's subsidies were relatively modest, and that the ministry was far from infallible in its choice of industries on which to bestow advice and financial support. Hugh Patrick, professor of economics at Columbia University, points out that while some of MITI's targeted industries (such as microelectronics and computers) performed well, others (such as commercial aircraft and shipbuilding) did not. And although MITI did not target the automobile and consumer-electronics industries, they thrived beyond

by Jonathan B. Tucker



anyone's expectations without government favors.

Moreover, even when MITI had strong enforcement tools such as control over imports of foreign technology, its power over private industry was not absolute. During the mid-1960s, the ministry advised Japan's eight automobile manufacturers to merge into three major groups, each specializing in one category of cars, in order to achieve economies of scale and to improve the industry's international competitiveness. But MITI's directive went unheeded in the face of strong industry opposition.

Thomas Pepper of the Hudson Institute (Washington, D.C.) contends that MITI's industrial policy was far less important to Japan's rapid postwar growth than was a confluence of macroeconomic and historical factors, including United States defense guarantees, a stable political system, the abundance of skilled managers and cheap but motivated labor, the availability of Western technology, an economic climate favorable to investment, the undervaluation of the yen, and the great size and rapid growth of consumer demand.

Crisis and recovery. After the boom years of the 1960s, the early 1970s were a period of deep crisis for the Japanese economy. Publication of *The Limits to Growth*, an influential Club of Rome study that used computer models of the global economy to predict environmental and resource constraints on economic growth, triggered near-panic in Japan and fueled land speculation and high inflation. At the same time, MITI's policy of fostering unrestrained industrial growth at the expense of social programs and environmental protection began to meet with public resistance. By the early 1970s, severe pollution—particularly from the antiquated caustic soda and chlorine

A fully automated factory operated by Matsushita manufactures circuit boards for television sets.

industry—was causing a disturbing rise in certain diseases. Perhaps the most frightening incident was the outbreak of Minamata disease, a grotesque congenital abnormality caused by the consumption of fish contaminated with high levels of mercury.

Mounting public discontent over the social costs of rapid industrialization sparked large environmental and consumer movements in Japan, which accused MITI of being in league with big business and acting against the public interest. After a period of soul-searching, MITI supported citizens' demands for the creation of an Environment Agency in the Prime Minister's office to regulate industrial pollution. Soon afterward, the 1973 oil crisis and the subsequent global recession battered the Japanese economy. Since the government had been taking fiscal measures

to fight inflation, the country was hit particularly hard by the sudden outflow of capital and the foreign-exchange deficit. The soaring costs of energy, imported raw materials, and labor caused 14 smokestack industries (including petrochemicals, pulp and paper, aluminum smelting, shipbuilding, and artificial fibers) to become "structurally depressed," or chronically non-competitive on world markets. The shipbuilding industry, for example, had greatly expanded its capacity for building oil tankers in the 1960s. Then, when the price of oil skyrocketed and consumption dropped, Japan was left with a large surplus of shipbuilding capacity.

Seeking to address the severe economic



Keijiro Murata heads the Ministry of International Trade and Industry (MITI).

Expo '85

Sprawled across 250 acres near the city of Tsukuba (about 30 miles north of Tokyo), Japan's colorful international science showcase is actually one part advanced technology, ten parts mass entertainment. Expo '85 opened in March of this year; it will have received some 20 million visitors by its scheduled closing in mid-September.



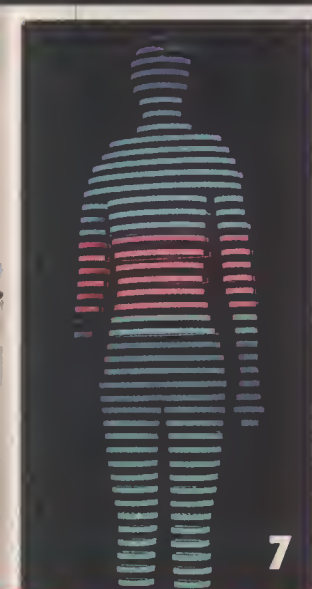
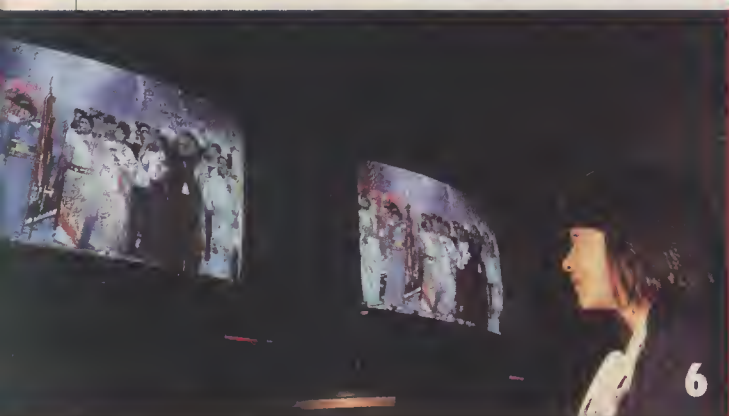
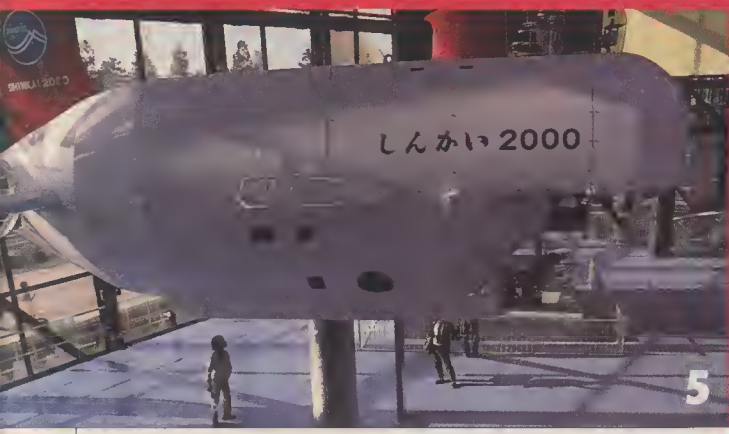
crisis, MITI pushed for a massive restructuring of Japanese industry. In a long-range planning document called "Visions for the 1970s," the ministry recommended a major shift in investment away from energy-intensive heavy industries and petrochemicals in favor of "knowledge-intensive" light industries, which would consume less energy and raw materials. Because of the gravity of the economic crisis, the Japanese Diet (Parliament) granted MITI, the Ministry of Finance, and the Bank of Japan extraordinary powers to implement the new policy.

MITI's newfound authority was particularly strong with respect to the structurally depressed industries. In an

effort to minimize the social and political dislocations of the industrial transition, MITI provided financial aid to laid-off workers and obtained legal exemptions so that depressed industries could form production cartels to stabilize prices. In return, the affected companies agreed to make coordinated cutbacks in production and to retrain workers for jobs in other industries.

In large part because of its restructured economy, Japan was able to weather the second oil shock of 1979 with much less disruption than it had suffered in 1973. The government also began to shift from an industry-first policy toward greater emphasis on social programs. By the early

INDUSTRIAL POLICY



1. With a screen 75 feet high, Sony's Jumbotron TV welcomes Expo visitors from almost a mile away. **2.** In the Japanese government pavilion, lettuce raised in a controlled atmosphere grows at 4-5 times the normal rate. **3.** Mitsubishi's four-legged robot uses tiny sensors on each foot to produce graceful, lifelike movements. **4.** Expo's battery of robots can draw your picture, play the organ, or just kill time spinning a top. **5.** The Japanese government's marine technology exhibit features a miniature exploratory submarine. **6.** Toshiba claims that its high-definition TV will create images as clear as those of 35mm movies. **7.** A colored map of the human body guides visitors through a CT scanner demonstration in the Japanese government pavilion.

1980s, government loans to industry had declined to about 10% of total public investment, while housing loans had increased to 32%. Even so, living standards in Japan still lag behind those of other advanced capitalist countries. A recent study by the Ministry of Construction found that about half the roads in Japan still lack sidewalks, only three out of every ten homes are linked to a sewer system, and one tenth of Japan's 120 million people live in substandard housing and hygienic conditions.

Today, industrial policy in Japan is not simply imposed from above, but emerges from a continual process of consultation between government and industry. To convince the

private sector to comply with its policies, MITI uses "administrative guidance," a uniquely Japanese form of official persuasion. Since the ministry's statutory powers are limited, it does not attempt to enforce its will through the legal system. If it did, companies might challenge it successfully in the courts. Instead, MITI backs up its advice with a variety of carrots and sticks. The carrots include subsidies, tax incentives, and directed research and development projects; the sticks include gentle arm-twisting and implicit threats of new legislation. Even so, private firms are likely to resist administrative guidance if they believe their interests diverge significantly from MITI's definition of the national interest.

Soft guidance. One of the ministry's most effective "soft" tools for achieving influence is to work with industry and other interest groups to build a unified "vision" of Japan's future industrial structure that will best meet the changing conditions of the international marketplace. The forums for vision making are some 30 MITI-chartered "deliberative councils" such as the Industrial Structure Council and the Industrial Technology Council. Included in the councils are representatives from trade associations, government, academia, mass media, labor, and consumer and public-interest groups.

These various bodies discuss which industries and technologies are most important for the country's economic growth and hence should be targeted for special favors, and which industries are becoming noncompetitive and thus should be phased out. The consensus that emerges from the vision-making process is then published and distributed throughout Japan. Although this document is intended to serve as a basis for corporate strategic planning, the extent of compliance is left up to the private sector.

Richard J. Samuels, professor of political science at MIT and director of the MIT-Japan Science and Technology Program, describes the vision-making process as a form of "reciprocal consent." In exchange for the use of public resources, private industry grants the state the power to define industrial structure in the national interest. This process benefits everyone by creating a stable framework for economic growth.

In formulating industrial policy, MITI's primary goal is to create orderly markets with a limited number of strong competitors. "While the U.S. is concerned that excessive concentration of economic power will lead to monopoly," says Samuels, "MITI's greatest fear is that excessive competition will lead to chaos." This is why MITI tolerates production cartels and the concentration of economic power in giant financial/industrial groups such as Mitsubishi and Mitsui (see "Business in Japan," p. 28).

The Japanese also view the international marketplace—not just the domestic economy—as the standard against which a company's market share should be measured. As a result, antitrust regulations are much less stringently enforced in Japan than in the U.S. After World War II, the Allied occupation authorities imposed on Japan an antimonopoly law and an antitrust regulatory agency called the Japan Fair Trade Commission, which was modeled after the U.S. Federal Trade Commission. But the philosophical underpinnings of these institutions remain largely alien to Japan's corporate culture. "The Japanese don't feel that antitrust is a necessary component for achieving economic efficiency," says William F. Finan, former special assistant to the U.S. under secretary of commerce for international trade and now a principal specializing in electronics at the consulting firm of Quick,

Business in Japan: big and small

As Japan began to industrialize in the mid-19th century, economic power came to be highly concentrated in a few family-owned groups of industrial companies. By World War II, these mammoth combines, known as *zaibatsu*, controlled much of Japanese industry, commerce, and finance. At the end of the war, the Allied occupation authorities broke up the *zaibatsu* because of their close ties with the Japanese military, but they later reemerged in the form of six giant industrial groups centered around a major bank or trading company. Today these finance-centered groups—Mitsubishi, Mitsu, Sumitomo, Fuyo, Dai-ichi Kangyo, and Sanwa—once again dominate Japanese industry.

Each group is made up of companies representing every major sector of the economy, including energy, steel, chemicals, pulp and paper, shipping, construction, heavy machinery, electronics, retailing, and financial services. The Mitsubishi Group, for example, consists of about 45 companies with worldwide sales in 1983 of \$140 billion.

The companies within each finance-centered group are linked by interlocking directorates, mutual stock ownership, supply and marketing agreements, and joint development of new business lines. In addition, the companies rely for capital on the group's bank or trading company and thus have little need to sell shares on the stock exchange. This reduced dependence on equity and stockholders enables the group companies to enjoy a longer planning horizon than most U.S. firms. The diverse holdings of the finance-centered groups have also helped to smooth the transition of the Japanese economy from heavy machinery and chemicals to high tech industries by allowing workers to be transferred from one company to another within the group.

Allied with the six finance-centered groups are seven big industry-centered groups—Nippon Steel, Toshiba, Hitachi, Toyota, Nissan, Matsushita, and Tokyu—characterized by vertically integrated operations within a single industry or related industries. In contrast to the loose coordination of companies within a finance-centered group, the companies within an industry-centered group are managed as though they were divisions of one giant corporation. Since these groups do not include a financial institution, they tend to sell shares to meet most of their capital needs.

The 13 industrial groups have certain common interests and often cooperate in government-initiated programs intended to develop promising new areas of technology. At the same time, however, the firms within each industrial sec-

tor compete vigorously for market shares and influence in government. That each of Japan's major industries has several big companies competing on nearly equal terms has been key to the country's success in international trade. Without this vigorous domestic competition, 25 years of protectionist trade policies could not have yielded companies that today compete so effectively in global markets.

Although the giant industrial groups represent an extraordinary concentration of economic power, they exclude many of Japan's most innovative and dynamic firms, such as Honda, Sony, and Pioneer. In addition, two-thirds of the Japanese economy is made up of small firms of less than 100 employees. While the big assemblers are unionized and provide good benefits and guaranteed lifetime employment, the workers in the small companies receive lower wages, have poorer working conditions, and do not enjoy the same degree of job security.

Each big manufacturer relies on a large number of small parts suppliers and subcontractors, known as *shitauke*, which usually work for it exclusively. Many of these firms are technologically advanced and can fabricate whatever parts the big assemblers require. "Throughout the manufacturing sector, and particularly in automobiles and electronics, a higher proportion of value-added comes from the suppliers than from the final assemblers," says Robert E. Cole, professor of sociology and business administration at the University of Michigan (Ann Arbor). This dual industrial structure has enabled Japanese manufacturers to introduce new and improved products rapidly, giving them a competitive edge in international markets.

The relationship between the large manufacturers and their suppliers is both hierarchical and mutually beneficial. While the *shitauke* are entirely dependent on the assemblers for their financial survival and suffer the impact of economic downturns disproportionately, the big manufacturing firms put a lot of effort into upgrading the performance of their suppliers, including financing the purchase of new equipment. In addition, each large assembler typically owns a small amount of equity in its suppliers (5–8%) as a way of cementing the relationship.

"The major strength of the system is accountability," says Cole. "By keeping their suppliers independent and at arm's length, the big assemblers have more clout in demanding increased productivity and quality. At the same time, the suppliers are closely integrated into the production system."

Finan & Associates (Washington, D.C.).

Indeed, while U.S. antitrust officials block corporate mergers that would jeopardize domestic competition, MITI has encouraged mergers, production cartels, and price standardization that will enhance the international competitiveness of Japanese industry—even at the expense of domestic competition. And although the Japan Fair Trade Commission has consistently opposed MITI's pro-merger, pro-cartel policies, it has had little real power to enforce its views.

Research and development. Complementing MITI's industrial policy are government policies dealing with research and development. Of the \$23 billion Japan spends annually on R&D (2.6% of the country's GNP), the amount contributed by the government is surprisingly small. While the U.S. government provides about half the United States' R&D funding, the

Japanese government pays directly for only 25% of Japan's R&D. Nevertheless, the Japanese government provides many indirect subsidies for private-sector investment in R&D, including R&D tax credits, accelerated depreciation for new R&D facilities, and low-interest loans through the state-owned Japan Development Bank.

Today Japan has some 300,000 full-time researchers—a number exceeded only by the United States and the Soviet Union. And although Japan's population is only about half that of the U.S., Japanese universities produce more graduates in scientific and technical fields than their American counterparts. Japan has also become less dependent on Western nations for its technology. Since 1975, Japan has licensed more of its own technology abroad than it has imported foreign technology (although when payments for old licenses are included, Japan is still a net importer). In 1981, for example, new contracts for Japanese technology exports were valued at \$314 million, while new contracts

for technology imports were valued at \$111 million.

In addition to being heavily focused on industry, Japanese R&D is oriented almost entirely toward the civilian economy. Japan is restricted by its postwar constitution to a small military establishment and hence relies on the U.S. for its security. Only about 2% of the Japanese R&D budget goes to military research, compared with more than 50% in the U.S. Thus while the total U.S. research pie is much larger, Japan spends nearly the same amount on civilian R&D. Since most military systems are low-volume and high-cost—precisely the opposite of what is required in the civilian marketplace—large U.S. expenditures on military research have yielded few direct economic benefits and have allowed Japan to pull ahead in several key industrial sectors, including consumer electronics, integrated-circuit production, carbon fibers and ceramics, and amorphous-silicon solar cells.

R&D policy in Japan is made by several government agencies, which often compete fiercely among themselves for control over the most promising new areas of technology. At the top of the policymaking hierarchy is the Council for Science and Technology, chaired by the Prime Minister, which sketches the broad outlines of Japan's technological agenda and places its imprimatur on plans developed by various agencies of the bureaucracy.

Large technology projects, such as the Japanese space program and nuclear fusion research, are the bailiwick of the Science and Technology Agency (STA), which also does long-range planning on the nation's science and technology needs and prepares an annual White Paper on trends in Japanese science. The agency funds three public corporations staffed by non-civil servants: the National Space Development Agency, the Japan Atomic Energy Research Institute, and the Power Reactor and Nuclear Fuel Corporation. STA therefore combines some of the functions of several U.S. government bodies, including NASA, the Department of Energy, and the White House Office of Science and Technology Policy.

Also partially funded by the STA is a public corporation called the Japan Research and Development Corporation (JRDC), which transfers the results of research conducted at universities and national laboratories to private industry through contracts and licensing arrangements. JRDC also coordinates an innovative program known as Exploratory Research for Advanced Technology (ERATO). Established in 1981, ERATO brings together scientists from different fields to work on interdisciplinary areas of technology that are far from commercialization but may yield major breakthroughs in the future. Current ERATO projects include research on ultrafine particles, amorphous and laminar materials, fine polymers, perfect semiconductor crystals, and biological control systems.

The main government body responsible for industrial R&D is the Agency of Industrial Science and Technology (AIST), a branch of MITI. This agency employs about 300 bureaucrats and runs 16 national laboratories staffed by some 3500 scientists, who perform research in fields ranging from advanced materials and electronics to production engineering. Nine of the national labs are located in Tsukuba Science City, north of Tokyo. Another branch of MITI, the Machinery and Information Industries Bureau, runs the Institute for New Generation Computer Technology (ICOT), where research is under way on the well-known Fifth Generation Computer Systems project. In addition, the various functional ministries—Construction, Transport, Education, Health and Welfare, and Posts and Telecommunications—sponsor R&D in their respective areas



CHUCK O'NEARY/WESTLIGHT

A Toshiba engineer examines the design of an IC chip, which represents one of Japan's top technological priorities.

and compete for influence with STA and AIST. And Nippon Telegraph & Telephone (NTT), a former state-owned monopoly that was privatized last year, is second only to AT&T/Bell Laboratories in the amount and quality of its telecommunications research.

Cooperative R&D. Since 1971, MITI's AIST has launched a series of national technology projects in which it provides grants or soft loans to groups of companies that agree to cooperate for a set period of time on developing specific new technologies. The ideal projects for cooperative R&D are those in which developing a desired technology would require a greater investment of money and manpower than any single firm could undertake on its own. Since AIST limits competition by inviting only the leading companies in a given field to participate, each national project must be exempted from the Antimonopoly Law.

To ensure that the national projects are geared to industry's needs, each proposal undergoes a three-year review process by the relevant trade associations and deliberative councils. After a project has been approved, AIST creates a research association to coordinate and manage industry participation throughout the life of the project.

Japanese firms agree to participate in the national technology projects because AIST provides seed money, and because they benefit from knowing what the next genera-

NATIONAL TECHNOLOGY PROJECTS

MITI/AIST

PROJECT	YRS.	\$ (MIL.)	PURPOSE
Sunshine Plan—alternative sources of energy	1974–2000	1100 ¹	To develop coal liquefaction and gasification, solar power generation (especially amorphous-silicon solar cells), geothermal, and hydrogen energy.
Moonlight Plan—large-scale energy saving technology	1978–undecided	247	To develop magnetohydrodynamic (MHD) power generators, high-efficiency gas turbines, new types of storage batteries, fuel cells, a general-purpose Stirling engine, and chemical heat pumps.
Optical measurement and control system	1979–85	62.8	To develop optical sensors and transmission networks for conveying large amounts of information. The project will use a petroleum refinery to demonstrate the application of such systems to controlling plant operation and management.
Basic-chemical manufacturing methods using carbon monoxide feedstocks	1980–87	60	To develop technologies for the production of basic chemicals (i.e., ethylene glycol, ethanol, and acetic acid) from coal and natural gas.
Manganese nodule mining system	1981–89	80	To develop a hydraulic mining system for harvesting large quantities of manganese nodules from the deep-ocean floor.
High-speed scientific computers	1981–89	92	To develop advanced computer hardware. A basic experimental IC chip for high-speed devices has been produced. The next phase of the project involves trial production of a variety of highly integrated chips using Josephson-junction devices, high electron mobility transistors (HEMTs), and gallium arsenide field effect transistors.
Basic industrial technology for the next generation	1981–90	416	To stimulate R&D for next-generation technologies and to fully utilize the potential of private industry under a cooperative arrangement including companies, universities, and the government. The program focuses on three different areas, divided into a total of 12 projects: New materials: fine ceramics, high-function polymers, semipermeable membranes, electroconductive polymers, highly crystalline alloys, and composites. Biotechnology: bioreactors, mass cell culture, recombinant DNA. New devices: superlattice devices, three-dimensional circuit devices, devices resistant to adverse ambient conditions.
Automated sewing system	1982–89	52	To develop an automated continuous sewing system for the textile industry, which has been labor-intensive because of a complex production process.
JUPITER (Juvenescent Pioneering Technology for Robots)	1983–90	80	To develop advanced robot technology to replace humans in dangerous work environments such as nuclear power plants and undersea operations.
Resource exploitation observation system	1985–90	92	To develop an observation system for earth-resources satellites. AIST will conduct the project jointly with the Science and Technology Agency.
Aqua Renaissance 90	1985–91	52	To develop a bioreactor capable of processing and purifying waste water.
Interoperable databases	1985–92	80	To enable databases with different operating systems to exchange information.

OTHER MITI PROJECTS

Fifth Generation computers	1979–91	47 ²	To develop advanced computers that will use artificial intelligence to make them easier to run. The first three years of the project concentrated on basic studies. The Institute for New Generation Computer Technology (ICOT), established in 1982, is entering a new phase in which it will concentrate on developing an inference system, including a parallel processing architecture and a knowledge base. (Machinery and Information Industries Bureau)
SIGMA (Software Industrialized Generator and Maintenance Aids)	1985–89	100	To develop an automated system for producing software. (Machinery and Information Industries Bureau)
Water desalination system for smaller plants	1985–89	.08	To develop a desalination process based on vapor-permeation membranes to replace costly distillation and reverse-osmotic membrane systems. (Industrial Location Bureau and Environmental Protection Bureau)

¹Total to fiscal year 1985.
²Initial commitment. Expected total: \$250 million.

This chart lists Japan's major technology projects, led by the government with broad participation by industry. The Agency of Industrial Science and Technology (AIST), the main promoter of these projects, is a branch of the Ministry of International Trade and Industry (MITI). A few other MITI projects are run by specialized bu-

reaus within the ministry, such as the Machinery and Information Industries Bureau. The Japan Research and Development Corp. (JRDC) sponsors the Exploratory Research for Advanced Technology (ERATO) program, which fosters the development of potentially revolutionary technologies that are far from commercialization.

ERATO

PROJECT	YRS.	\$ (MIL.)	PURPOSE
Ultrafine particles	1981-86	8	To explore the characteristics of ultrafine particles (less than a tenth of a micron in diameter) for applications in recording media (such as magnetic memories), light absorbers, catalysts, and filters.
Amorphous & intercalation compounds	1981-86	8	To design and synthesize new inorganic materials for industrial use by modifying the atomic configuration of existing metals, semiconductors, and ceramics.
Fine polymers	1981-86	7.2	To develop a new generation of synthetic polymers by taking as models the sophisticated functional capabilities of living organisms.
Perfect crystals	1981-86	8	To develop a new generation of semiconductors by combining perfect crystal growth technology with static induction transistor (SIT) technology.
Bioholonics	1982-87	7.2	To study "holonic" systems in biological organisms, in which molecules, cells, tissues, and organs interact cooperatively at various levels of organization, and to build models of such systems.
Bioinformation transfer	1983-88	7.2	To elucidate the mechanisms of action of neuroactive substances such as prostaglandins and leukotrienes, which play a crucial role in intercellular information transfer. The project aims to apply these mechanisms to medical problems and information technology.
Superbugs	1984-89	7.2	To search for microorganisms that grow under extreme environmental conditions, such as high acidity, temperature, salinity, and pressure, and to analyze their tolerance mechanisms and metabolic pathways. A possible result may be new bioreactors that can operate at higher temperatures.

Source: National Science Foundation/Tokyo office

tion of useful technology and products will be. "Most of the companies go along with the projects because they want to stay on good terms with MITI and don't want to be frozen out of any information that's developed," says Justin Bloom, former science counselor with the U.S. Embassy in Tokyo and now president of Technology International, a consulting firm in Potomac, Md. "And because of the Japanese tendency to maintain consensus, they feel that they have an obligation to participate."

Although the companies taking part in a national technology project work toward a common goal, actual inter-company cooperation is limited. Each company works on a separate task, includes only a few engineers from rival companies on its team, and does not disclose unique technical secrets or know-how. Once the targeted generic technology has been developed, the firms compete intensely to bring their own products to market.

So far, the most successful of the national projects has been the Very Large Scale Integration (VLSI) Project of 1976-79, which yielded important advances in semiconductor manufacturing technology. AIST funded about half of the project, in the form of a \$120 million loan repayable from future profits. The investment paid off: The VLSI Project helped Japanese firms to carve out a large share of the market in 64K random-access memory chips.

MITI is currently providing partial funding for 15 national technology projects, each involving 5-15 companies (see table). The most recent is the Sigma Project, a five-year effort to automate the writing of software. Virtually all computer programs in Japan are now written by hand, creating a severe manpower shortage in the software industry. MITI hopes that successful completion of the Sigma project will make it possible to automate 80% of software writing. (In the meantime, the Japanese have begun subcontracting some of their software writing to South Korea, Taiwan, India, and, most recently, China.)

The contribution of cooperative R&D to Japan's industrial success has been mixed. On the one hand, the national

technology projects have benefited Japanese industry by reducing redundant research and providing economies of scale. "Cooperative R&D has diffused know-how to more Japanese companies and gotten them into the marketplace faster and at lower cost than otherwise would have been the case," says Finan of Quick, Finan & Associates. And by enabling competing firms to agree tacitly on a common ground for competition, the national technology projects have created more orderly markets and facilitated the diffusion of industrywide standards.

On the other hand, joint R&D has probably yielded no products or processes that would not otherwise have been developed. Indeed, some Japanese businessmen claim that the national projects have hindered innovation by reducing the diversity of technological approaches being tried and by drawing money away from more competitive projects that might have been undertaken by individual companies. A growing number of Japanese companies are also reluctant to share information with competitors—particularly in fields like biotechnology, where the path from basic research to commercial products and processes is short. As a result, several of Japan's leading biotech companies have declined to participate in the national project in this area.

Creating new knowledge. Japan has long emphasized applied research and engineering at the expense of basic science. Government and industry allocate approximately 60% of total R&D expenditures for development of new products and processes, 25% for applied research, and only 15% for basic research. The low priority of basic research is also reflected in the educational system. While American universities produce about as many scientists as engineers, Japanese universities turn out nearly seven engineers for every scientist. Many talented scientists also choose to pursue careers in industry rather than academia. Thus, despite Japan's genius in commercializing new technologies, it lags behind the West in such measures of scientific innovation

as published papers and Nobel Prizes.

In recent years, however, there has been a growing recognition in Japan that neglect of fundamental research has become an obstacle to future economic growth. Having caught up with the West in many areas of technology, Japan can no longer simply license patents and know-how from more advanced countries. New scientific discoveries and inventions will be crucial if Japan is to compete in areas of technology closely tied to basic research, including aerospace, new materials, biotechnology, computer science and microelectronics.

A major impetus for Japan's growing commitment to fundamental research is the fear of a "technological blockade," a rise of protectionism in the U.S. and Europe that will prevent Japanese companies from obtaining leading-edge technologies developed in the West. Indeed, some Japanese researchers and firms have already been denied access to scientific documents, conferences, databases, and patent licenses, and barred from importing sensitive products or acquiring U.S. subsidiaries.

Concerned that the 1990s could be an era of technological blockades, Japan is investing in R&D facilities abroad. In April, for example, Mitsubishi Electric opened a new U.S. subsidiary called Horizon Research (Waltham, Mass.), which plans to employ six Japanese and 31 American research engineers by the end of the year. Mitsubishi's apparent objective is to keep tabs on new developments in Boston's high technology community. Japan is also moving to strengthen its own scientific base. Already, leading Japanese electronics firms such as Toshiba, Hitachi, Sanyo, and Matsushita are building laboratories devoted to research on new materials and processes rather than specific products.

This past February, MITI and the Ministry of Posts and Telecommunications presented a bill to the Japanese Diet to establish a Basic Technology Research Promotion Center, which will provide conditional, interest-free loans for private firms to do basic research in mining, manufacturing, telecommunications, and broadcasting. In addition to funding individual projects, the center will coordinate basic technology projects between national laboratories and private firms. Foreign researchers will also be invited to participate. The proposed center will be jointly funded by the government, the Japan Development Bank, and the private sector, and staffed and run by private companies and independent experts, with MITI's guidance.

In addition, the Japanese Ministry of Education (Monbusho) is working to strengthen the ties between industry and the national universities. In 1983 the ministry introduced new regulations to make it easier for industry to gain access to analytical equipment in university labs in exchange for funding basic research. Monbusho has also realized that the rigid hierarchy of the university research system, in which chaired university professors distribute all research funds as they see fit, often suppresses the initiative and creativity of young scientists. The ministry has therefore made some tentative steps to reform the system—for example, by allocating about 8% of its academic research funds to direct grants for young scientists.

It is often suggested in the West that the strong emphasis in Japanese culture on group identity and teamwork rather than individual achievement militates against innovative research. But many observers believe that the Japanese will rise to this new challenge, as they have in the past. "Perhaps the 'technological blockade' was just what Japan needed to propel it onward on its path to becoming a world leader in science and technology," writes Donald L. Philip-

pi, editor of *Japan Intelligence*, a monthly newsletter on Japanese technology.

A **cloudy future.** Despite its present economic strength, Japan will soon face major challenges, such as rising costs for raw materials and strong competition from the "four dragons" of the Pacific Rim—South Korea, Taiwan, Hong Kong, and Singapore—which are rapidly improving their technological capabilities while maintaining wage scales considerably below those of Japan. To a large extent, cheap imports from these "mini-Japans" have already displaced older Japanese industries such as shipbuilding, steel, and textiles.

As the newly industrializing countries of East Asia start churning out mass-produced consumer electronics goods, says MIT's Samuels, the Japanese have no choice but to move up the ladder to higher technologies, such as advanced semiconductors, optoelectronics, factory automation equipment, software, and integrated systems. "We hope for a horizontal division of labor on the Pacific Rim," says Yohei Mimura, president of Mitsubishi (Tokyo). "And the leader in this will, of course, be Japan."

But Japan's strong push into high technology export markets is worsening trade frictions with the U.S. and Western Europe and risks provoking protectionist measures that would jeopardize Japan's prosperity. Thus MITI's greatest challenge in the coming years may be to "harmonize" Japan's industrial policy with the policies of its Western competitors. "Japan is investing in R&D that will advance the development of its own, fairly innovative technology and strengthen its bargaining position," says Mimura. "But at the same time, Japan recognizes its responsibility to participate in international cooperative research that will contribute to the economic health of the world as a whole."

Despite the challenges facing Japan, MITI's ability to control private industry is waning as the Japanese economy becomes more liberalized. "Because of the growing complexity of the economy, consensus is becoming harder to achieve, and MITI's influence is bound to weaken," says Finan. Financial deregulation is also freeing market forces to play a greater role. Within the past five years, for example, a venture capital market has appeared in Japan that has supported the creation of more than 500 high tech start-up companies. Still, the total amount of venture capital in Japan is less than 10% of that in the U.S. And although many of the new start-ups are autonomous, "in some cases when you look behind the veil, the money actually comes from major Japanese corporations such as Fujitsu and NEC," says Finan.

The extent to which the Japanese government will continue to "manage" the economy is a matter of debate. Peter Fuchs, a research associate in the U.S.-Japan Program at Harvard University, observes that MITI is assuming a number of new functions, such as organizing cooperative basic-research projects, protecting Japan's access to foreign markets, developing intellectual property law (e.g., legal protection of software), and monitoring Japan's international competitiveness in various fields of technology. Overall, however, the private sector is taking the lead in charting the course of the Japanese economy, with MITI playing a secondary but still important role as resource and facilitator. Concludes MIT's Samuels, "Private firms are establishing their own strategies for competition in the marketplace, and channeling the government's industrial policy to their own benefit." □

Taking the work out of photography

OSAKA—If there is one product that symbolizes modern Japanese technology in Western eyes, it is the camera. Since World War II, Japan has come to dominate the photographic market with a reputation for competitive prices and very high quality. The country's leadership covers the range of cameras from the sophisticated "systems" used by professionals to the simple "point and shoot" devices that can be used by the most inexperienced amateur. Even in the arcane world of optics, Japanese lens designers have matched and now overtaken the once preeminent Germans.

Today, Japan produces about 17 million 35mm cameras annually—of which more than 80% are exported, mainly to the U.S. Unlike the automakers, Japan's camera manufacturers are not worried about the possibility of U.S. import restrictions; despite the huge numbers, cameras account for less than 1% of the value of manufactured goods. Nonetheless, Japan's "big five" camera manufacturers—Canon, Minolta, Nippon Kogaku (maker of Nikon), Olympus, and Asahi Optical (maker of Pentax)—are very much concerned about the dynamic U.S. camera market. Because it is "the world's fastest-growing market for 35mm cameras," says Masahiro Tanaka, managing director of Canon's Photo Products Group in Tokyo, "we have to anticipate the future needs of American consumers."

Canon and the other Japanese camera giants realize that the U.S. camera buyer wants both simplicity and quality. Kodak expressed the philosophy years ago with the old Brownie box camera: "You press the button and we do the rest." Japan's camera makers have taken that ideal to heart, and appear to have actually fulfilled it. The result has been the startlingly rapid acceptance around the world of the automated compact 35mm camera. Almost 10 million of these pocket-sized machines were produced in 1984, introducing many amateurs to a vastly higher level of picture taking.

For less than \$150, products such as the Nikon L35AF, the Olympus Quick Shooter, and the Pentax Super Sport offer automatic exposure control, automatic focusing, motorized loading and winding, automatic flash, and even

by Jeffrey N. Bairstow



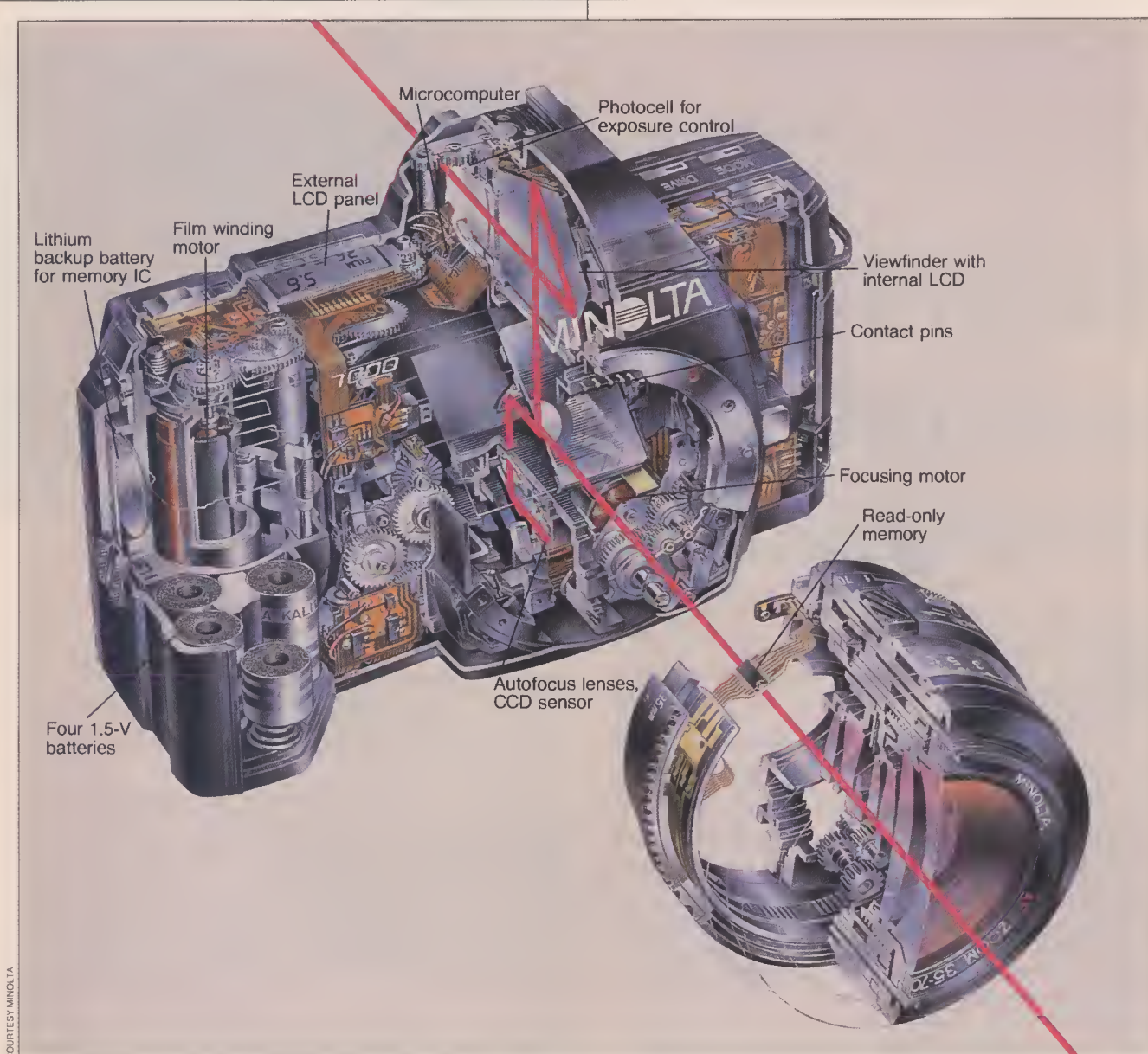
Japan's camera makers dominate the automated 35mm compact camera market with high-quality models like this Olympus Quick Shooter.

automatic film-speed setting with new encoded film cartridges. The photographer has to do no more than open the back of the camera, drop in a cartridge of film, extend the film leader, and then close the back. The camera advances the film to the first frame, sets exposure and focus when the shutter release is pressed, and advances the film to the next frame automatically.

The advance most responsible for making the fully automatic compact camera possible was the development of active autofocus systems (HIGH TECHNOLOGY, Nov./Dec. 1982, p. 53), usually based on infrared: A pulse is bounced off the object, the intensity of the reflected light is measured by a photodiode, and a motor then moves the lens until proper focus is achieved. An active autofocus system is simple and reliable and has excellent focusing accuracy. And because it will work in total darkness, it can be used with the flash unit that is an integral part of the compact camera.

The compact 35mm camera has fast become a mature technology, says Yoshihisa Maitani, assistant executive director of the Consumer Products Div. of Olympus Optical Co. "We've solved most of the technical problems. Now we are trying to reduce both size and cost." For example, Olympus has recently tackled the problem of power consumption with its new Quick Shooter. Some automatic flash cameras use so much energy for the winding motor, the flash, and the associated circuitry that conventional alkaline-manganese cells are exhausted after less than half a dozen rolls of film. But Olympus, with Matsushita and Duracell, has developed a twin-cell lithium battery pack that occupies much the same space as a pair of AA cells. Although its cost is three or four times that of alkaline cells, it has a usable life of approximately five years.

Other camera makers agree with Maitani's assessment of the technical maturity of the 35mm compact camera. "Now you will see more emphasis on precision and extension of existing capabilities," says Naoyuki Uno, director of the camera research and design department of Asahi Optical Co. For example, he anticipates consumer demand for a telephoto lens for small cameras, as does Tadao Tsuruta, general manager of the camera design department of Nippon Kogaku (Nikon). Tsuruta's likely approach



COURTESY MINOLTA

The Minolta Maxxum 35mm single-lens reflex camera has focusing motor, sensors, and microprocessor built into the body so that a lens of any focal length—currently up to 300mm—can be used. Through contact pins on the body, a read-only memory in each lens provides the microprocessor with data on the properties of the lens, while a digitizer on the lens focusing ring supplies information on the focus setting. Auto-

focus lenses and a CCD sensor in the body can then focus the camera by comparing images of the subject. Film data, shutter speed, and aperture setting are shown by LCDs on the camera body and inside the pentaprism viewfinder. The level of automation in the Maxxum has necessitated a considerable amount of electronics; integrated circuits in the camera contain the equivalent of 150,000 transistors.

to the problem would be to insert a flip-up lens inside the camera, thus maintaining its small size and essential simplicity.

The success of the compact automatic cameras, however, has saddled Japanese companies with a major marketing problem: how to arrest the decline in the sales of the bulkier but more versatile 35mm single-lens reflex (SLR) cameras. Long the workhorse of the professional photographer and the camera of choice for the serious amateur, the SLR camera requires a good deal of commitment from the occasional photographer. Indeed, the remarkably high-quality results achievable with the compact cameras may be causing a great many amateurs to conclude that the additional expense and complexity of the SLR camera

are simply not warranted.

Nonetheless, Minolta recently introduced a 35mm SLR camera, the Maxxum, with all the automated features of a compact camera at a price that is obviously aimed at an amateur who wants to upgrade. "We set out to design a camera that would recreate demand for the SLR," claims Mikio Naya, general manager of Minolta's Camera Engineering Div. in Osaka. Not only has the Maxxum been well received by the photographic press worldwide, but it has also caught the other major Japanese camera makers by surprise. "I admit we're impressed by the Maxxum," says Nikon designer Tsuruta, "by both its degree of automation and its remarkably low price." Will Nikon compete with the Maxxum? Tsuruta won't say, but the chances are that

Nikon and the others will have a competing entry before too long.

What Naya and his 300-engineer design team have done is to develop an automated 35mm SLR camera that can be produced economically. Other makers, notably Pentax, Canon, and SLR market leader Nikon, have offered cameras with programmed exposure control and autofocus, but those systems have been grafted onto existing camera and lens designs with less than spectacular results. Such products are clumsy and expensive, and their lenses are not as versatile as those of conventional SLRs. Weighing less than two pounds with a full set of batteries and a standard 50mm lens, the Maxxum feels and operates like a normal SLR. The difference is in the high degree of automation.

The Maxxum's autofocus system is almost all contained within the body of the camera. Consequently, a wide range of lenses, from wide-angle to telephoto, can be used. Each lens contains a small read-only memory that supplies data on the focal length and focus position of the lens. The Minolta phase-detection autofocus system works a little like a conventional split-image manual focusing aid: Two separator lenses project dual images of the subject onto a charge-coupled device (CCD) array of sensors. The autofocus microcomputer compares the signals from the sensors, and a tiny motor in the camera body rotates the lens until the signals are in phase and the subject is in focus.

Although this autofocus system is passive, relying on light from the subject, a specially designed flash unit permits the Maxxum to focus in the dark. The autoflash produces two bursts of infrared light that activate the autofocus unit, the first to measure the focus distance and set the lens and the second to check the focus setting immediately before the flash fires. The flash duration is also controlled by a sensor through the camera lens.



Masahiro Tanaka, managing director of Canon's Photo Products Group, demonstrates the T80, Canon's new autofocus SLR camera.

The Maxxum is a striking example of the use of electronics to control what is still essentially a mechanical device. According to designer Naya, almost 50% of the manufacturing cost of the Maxxum is in its electronics. The camera contains no fewer than three 8-bit CMOS microprocessors with memories of up to 4 kilobytes, plus another half-dozen integrated circuit interface units and drivers. Naya estimates that electronics may eventually represent as much as 75% of the cost of an automated SLR camera.

The lenses and mechanics of the Maxxum, though more conventional in design, are state-of-the-art. The shutter, for example, is a vertical traverse type that looks like a series of overlapping knife blades. The blades are operated by an electronically controlled solenoid to produce shutter speeds of up to $1/2000$ second. While that is remarkably fast, Nikon's engineers have further refined this type of shutter with ultra-lightweight titanium blades to achieve a shutter speed of $1/4000$ second in the FE2 camera. "That's probably very close to the limit for mechanical shutters," says Nikon's Tsuruta. "The next stage is the so-called shutterless camera using, perhaps, some form of liquid crystal."

Similarly, the 12 new lenses that Minolta is producing for the Maxxum, each containing a read-only memory with focusing data, are largely conventional in design, with one exception. The unusual lens is a tiny 35-70mm zoom that is barely larger than a conventional 50mm lens. Minolta uses a new technique for depositing a thin plastic coating on the rear of a normal cylindrical lens. This produces a compound aspherical lens that dramatically shortens the distance between elements and results in a radically smaller zoom. Although plastic lenses have been used in smaller cameras, such as Kodak's Disc units, this is the first appearance of combined glass and plastic lenses in a full-sized 35mm SLR.

Given that developments in 35mm camera technology are more likely to be refinements than breakthroughs, are Japanese camera makers looking at alternatives to conventional silver-based films? Several Japanese companies, notably Sony, Konishoroku (makers of Konica cameras), and Copal (a video camera maker), have displayed prototypes of video still cameras. These devices use CCDs and capture the electronic image on a small floppy disk. While the current size of production CCDs, about 200,000 pixels, is acceptable for images displayed on a TV set, video still cameras have a long way to go toward matching the resolution of silver halide films.

Japanese camera makers all have active R&D programs in still video, and several are working with semiconductor makers to produce larger-capacity CCDs. Canon's Tanaka expects that the company will introduce a video still camera later this year, with production slated for "some time in 1986." He admits, however, that the quality will be way below that of 35mm film. "We'd need at least a 4-million-pixel CCD to approach film quality," he estimates, "and that's several years away—particularly at a price the consumer will be prepared to pay."

But just as instant cameras have not caused the demise of silver halide film cameras, it seems likely that the video still camera will not displace the 35mm camera but will take its place in the array of options for recording images. In any case, Japanese camera makers will strive for a technical edge in all their diverse products. Says Harumi Aoki, Pentax's chief engineer for camera R&D: "If new technologies will make cameras more reliable, less expensive, and simpler to use, then we will employ them." □

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Pushing ahead in car technology

NAGOYA—For decades, Detroit was “the automotive capital of the world.” The giant U.S. automakers were leaders in both technical design and mass production. Today, the Japanese have quietly taken the lead in the automation of mass production, while technological leadership has passed to European automakers such as Mercedes-Benz and BMW. But the Japanese car manufacturers are moving rapidly ahead in the development and refining of automobile technology, and may soon take the lead there as well.

At the annual Tokyo Motor Show last fall, Toyota, Nissan, and Toyo Kogyo (maker of Mazda cars) showed prototypes with some remarkably advanced ideas. Toyota, for example, demonstrated two radically new autos: the FX-1 (a “new technology concept car”) and the SV-3 (a mid-engine two-seater sports car). The latter is now available in the U.S. as the Toyota MR-2, a vehicle that is getting rave reviews from the automobile press.

For a company that has built its success largely on cheap, reliable, unexciting “econoboxes,” these products represent quite a departure. The MR-2 not only looks like a sports car but performs like one; it exemplifies much of the work Toyota’s engineers have done in recent years to secure exceptional performance from relatively small engines. For example, the MR-2’s 1587-cc twin-cam engine, with four cylinders and 16 valves, produces 112 hp. And it uses a novel air intake system called T-VIS (for Toyota Variable Induction System), in which each cylinder has two intake valves instead of the usual single valve. One of the intake passages can be closed off automatically at low engine speeds, maintaining a high airflow speed for efficient fuel/air injection, and opened at high engine rpm for added air to keep the fuel/air mixture lean. The result is better performance over the entire engine torque range.

Similar enhancements are used in the 24-valve twin-turbocharger six-cylinder engine of the FX-1, a car that some industry observers expect to be the basis of the next model of Toyota’s extremely successful Celica Supra. The FX-1 is heavily dependent on electronics for both controls and displays. For example, it boasts an electronically con-

trolled suspension system that adjusts vehicle height, stance, damping force, and spring rates according to the load and performance of the car. Its braking is also controlled electronically to prevent wheel locking and skidding.

Moreover, in Toyota’s continuing quest for weight reduction and improved durability, the FX-1 makes extensive use of new materials, such as fiber-reinforced aluminum alloys for engine connecting rods, injection-molded urethane for bumpers and fenders, and ceramic cloth for exhaust pipe heat insulation. “Some of these innovations are already in use on domestic models of our cars,” says Mamoru Kaida, general manager of Toyota’s technical administration group. “Our policy is to introduce new technology first in Japan and then in our other markets when we are satisfied that it meets our customers’ needs and we can provide support.” Thus the FX-1’s sophisticated TV instrument panel is already available on the top-of-the-line domestic Soarer but probably won’t appear in the U.S. until a new model of the Celica Supra is introduced, possibly in 1986.

This conservative approach—reflecting Board Chairman Eiji Toyoda’s long-held philosophy of “good thinking, good products”—is intrinsic to the entire Japanese auto industry, even among manufacturers like Subaru, which have a reputation for technological innovation. Long a leader in front-wheel-drive and four-wheel-drive passenger cars, Subaru is now close to introducing a continuously variable transmission, or CVT (HIGH TECHNOLOGY, July 1984, p. 65), probably on the J10, a one-liter-engine minicar not currently sold in the U.S. But first, says Hiroyuki Nakamura, a senior engineering consultant in Subaru’s engineering division, several hundred Subaru cars with electronically controlled CVTs will have been used by company engineers and executives in a massive testing program that began recently. So far, the response of the test drivers seems to be universally enthusiastic, says Takemasa Yamada, one of the engineers using a CVT-equipped car for daily driving. “Acceleration is smoother and faster,” he says. “There is no shift shock, and fuel consumption is 25% lower.”

Almost every Japanese automaker now offers at least one model with four-wheel drive for the domestic market, but Subaru continues to maintain its lead worldwide, having introduced the first mass-produced four-wheel-drive passenger car in 1972 and passed the 1 million mark last year. On the domestic version of Subaru’s Turbo sedan, the four-wheel-drive system is fully automatic. Normally the car operates with two-wheel drive, but it switches into four-wheel drive under hard acceleration or braking—or when the windshield wipers are turned on, indicating that the road is wet and the superior road-holding qualities of four-wheel drive are required. This system may be available in the U.S. next year, according to Ryuichiro Kuze, general manager of Subaru’s overseas service division.

Another major Japanese trend is toward performance enhancement with turbocharging. (Indeed, the turbocharg-

by Jeffrey N. Bairstow

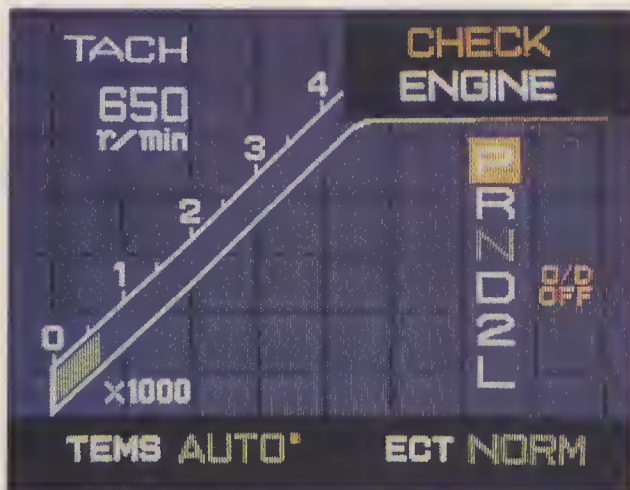


Toyota's experimental FX-1 "new technology car" has a 24-valve six-cylinder engine with twin turbochargers, an electronically controlled suspension, and color-TV dashboard displays. These advances are expected to appear in the next model of the Toyota Celica Supra.



Nissan's NRV-II research vehicle has the exterior of a conventional sedan but an interior that features large multicolor liquid crystal displays, a navigation system with maps shown on a color TV, and steering-wheel-mounted switches and indicators linked to the car's electrical system by fiber optics.

er is such a status symbol among Japanese motorists that auto stores offer "Turbo" trunk stickers so those unfortunate enough to have a non-turbocharged car can at least keep up in appearance if not performance.) Mitsubishi Motors, for example, has put a tiny turbocharger into the 1600-cc engine that powers the small Mirage hatchback, Mitsubishi's greatly improved version of the Colt previously sold in the U.S. by Dodge and Plymouth. With blades less than two inches in diameter, the exhaust turbine boosts engine power by some 25% to 102 hp, a hefty output for a



The TV display in the Toyota Soarer, a luxury model not exported to the U.S., shows maintenance needs and warns of trouble with the engine, transmission, or electronic systems. It can also be switched by the driver to show engine performance and fuel efficiency. At rest, the same display can receive TV broadcasts or show videotapes.

small engine. This engine also has a sophisticated electronic control system with an 8-bit microprocessor that monitors intake airflow, pressure and temperature, throttle position and engine rpm, engine water temperature, and exhaust gas oxygen. The microprocessor controls ignition timing, fuel mixture and flow, and turbocharger waste gas flow.

Extensive use of electronics for engine control has been a hallmark of Mitsubishi cars since 1980. More recently, the company's engineers, often in cooperation with Mitsubishi



This stockpile of auto engines at Mitsubishi's highly automated Shiga plant in Kyoto is deceptive. Like other Japanese automakers, Mitsubishi uses the "just in time" inventory system to keep less than one shift's production on hand.

Electric, have mated electronic components to suspension, steering, and other chassis-related functions. The 1985 Mitsubishi Galant sedan, available only in Japan, has microprocessor-controlled suspension, power steering, and engine mounts. Although the latter might not, at first sight, appear to require the sophistication of electronic control, Mitsubishi design engineer Hideo Umino points out that the spring constants required for reducing vibration at idle speeds are much lower than those needed under quick acceleration or deceleration. "So we developed a liquid-filled shock-absorbing mount whose fluid flow is controlled by solenoids operated by the computer," says Umino. The result is noticeably less body vibration.

Despite its commitment to innovation, however, Mitsubishi tries to avoid an overdependence on high technology. "With the current state of electronics, we can build complex systems for experimental use," says Umino. "But for commercial use we must be sure that electronics improve performance and function without becoming too complex or difficult to maintain." Consequently, the company has been concentrating on electronic systems that are relatively simple and have fail-safe provisions so that the car can be operated if the electronics fail.

Of the major Japanese auto manufacturers, Nissan has probably been the most aggressive in developing electronic systems that appeal to the Japanese love of gadgets. On the Bluebird, sold in the U.S. as the Maxima, Nissan offers an optional "safety drive adviser" that is billed as the world's first "drowsiness warning system." A microcomputer monitors elapsed driving time, weather (by noting use of windshield wipers), time of day, and driver behavior (through steering wheel movements); if measurement indicates that the driver is fatigued, the computer sounds an alarm. But despite its safety implications, a Nissan spokesperson acknowledges that the demand for the option has not been strong. Similarly, demand appears to have been unspectacular for Nissan's backup sonar system, which warns of objects

behind the car when it's moving in reverse.

Nonetheless, Nissan continues to experiment with complex electronic systems. For example, it is investigating navigation systems—such as loran (long range navigation), which is used worldwide by ships and aircraft—for application to ground vehicles. Coincident with the opening of Expo '85 at Tsukuba, Nissan installed such a navigation system in a delivery van for the local branch of the Tokyo-based Seibu department store (see "Vehicle navigation system," p. 7). The store's main computer produces a floppy disk with data for the day's deliveries. In the van, a microcomputer reads the disk and then displays an optimal delivery sequence and a local map on a color CRT. But although the system seems effective, the price tag is still prohibitively

high: around 2 million yen (about \$8000).

Another advanced system, being demonstrated on the company's NRV-II (for Nissan Research Vehicle), is a 24-gigahertz radar auto-cruise system that displays the separation distance from the vehicle in front. According to Nissan, the system also gives a verbal warning to the driver if the NRV-II gets too close to another car, and will even interrupt the cruise control. But Toshio Maeda, general manager of product planning for Nissan's technical center, admits that such systems are ahead of their time. They are still too expensive and complex for production vehicles, he says; what's more, "drivers may not want this type of control."

On the more practical side, Maeda notes that Nissan is researching the possible use of artificial intelligence techniques for engine control and overall car performance. "Just as a horse will notice its rider's behavior and perform accordingly," says Maeda, "we're trying to develop a driver interface that will adapt to the style of the driver. That way, the same car will perform differently in the hands of an aggressive, impatient driver than one who drives more slowly and cautiously." According to Maeda, such cars could become commonplace before the end of the century.

Despite some initial uncertainty about which innovations will appeal to the consumer and which ones will miss the mark, it does seem certain that Japan's auto manufacturers will grow to rely more heavily on new technology that they have developed themselves in response to carefully measured demand. "The impetus that keeps an industry young, that forces it to innovate, comes from the marketplace," says Kenichi Yamamoto, president of Toyo Kogyo (Mazda). "Social demands for energy and resource conservation have become stronger. And market requirements for greater value and improvements in performance, comfort, and safety have grown. These demands cry out for technological solutions." □

Lighting the way in lasers

KAWASAKI—For many years lasers were the playthings of laboratories all over the world. They were popularly referred to as “a solution in search of a problem.” Only recently, with solid-state lasers and low-loss glass fibers, has the tremendous potential of optical technology emerged. And Japan is especially well placed to assume global leadership in this frontier technology. Unlike cameras, automobiles, and more recently biotechnology, optoelectronics is a field in which the Japanese have done much of their own basic R&D. For example, Japan’s first patent for optical communication using guided light was granted in 1936 to a national Electro Technical Laboratory research group including H. Seimiya. The young researcher later became president of Fujitsu,

by Robert Haavind

which today is a leader in optical systems.

Japanese suppliers, such as Hitachi, NEC, and Fujitsu, have long been world leaders in laser emitters. But they are not resting on past glories. These companies as well as national laboratories are working on materials, processes, and devices suitable for a wide variety of optical systems.

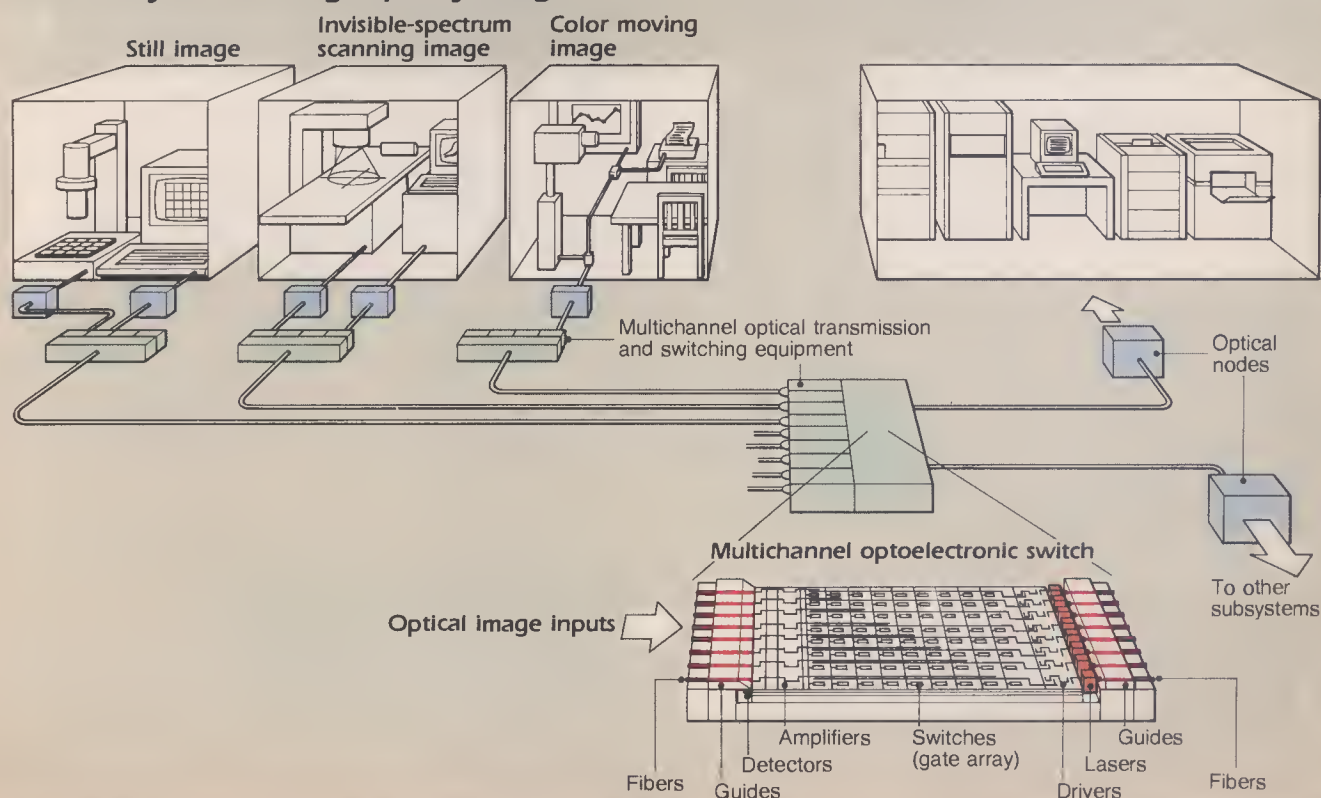
In communications, fiber optics promises wideband, interference-free transmission both for local links in factories and offices and for main trunks, on land and under the sea.

Already, Nippon Telegraph & Telephone (NTT) has installed an optical communications trunk system consisting of monomode fibers running from Hokkaido to Kyushu and carrying traffic ranging up to 400 megabits/second.

There is a second major reason why the Japanese are concentrating on this technology: They envision optically based home entertainment centers. These would include compact disc players for movies and other images, along with distortion-free sound. Color video would be fed to the home through optical cable TV links. Videodiscs could be hooked to a microprocessor and used interactively for new

Optoelectronic integrated circuits (OEICs) are being developed for optical systems of the future by several Japanese companies. The subsystem shown will require a highly integrated multichannel switch, being developed by Fujitsu, for 5-10 TV channels carrying a variety of images. Such gallium arsenide OEICs are still a few years off.

Data subsystem for high-quality images



types of games and instructional programs. Compact disc technology also appears ideal for mass digital storage; thousands of documents could be stored on a single disc.

Optoelectronics offers a casebook study of Japan's ability to coordinate a nationwide cooperative program while individual companies compete intensively to position themselves for what is expected to be a giant future market. Consider, for example, the Optoelectronic Project—a \$40 million, 6-year effort (now in its fifth year) aimed at developing advanced systems capabilities through a collaborative R&D program, including a national laboratory. It is the R&D portion of the Optical Measurement and Control System project initiated by the Ministry of International Trade and Industry (MITI) in 1979. Initially a large "system of the future" was conceived, consisting of interlinked optical subsystems. These might serve factories, office buildings, laboratories, and even homes. Critical components were identified, and fifteen companies were assigned to develop them. Other contracts covered specific processes or materials. A National Optoelectronics Laboratory in Kawasaki, outside Tokyo, was set up to do fundamental research and to coordinate R&D activities among the participants. Results are beginning to come in: An optical data collection and transmission system will be installed in an oil refinery this October to demonstrate the technology, according to Masahiro Hirano, head of research planning for the national laboratory.

The national lab primarily supports work on advanced devices, and about 50 researchers from nine of the companies in the Optoelectronic Project have spent time working there. Some specific devices under development include:

- Holographic image scanners, from NEC, for converting visible images to holograms and then using a scanning beam to transmit a holographic image. This could provide direct monitoring of fast-changing image data.
- Multichannel optoelectronic switches, from Fujitsu, that will receive optical data from fibers, feed them to detectors for conversion to electronic signals, switch several channels (perhaps 5–10 television channels), and then feed driver circuits for laser diodes.
- Data control subsystems, from Hitachi, that will combine all signal transmissions in a full-scale optical system. This will require high-speed semiconductor lasers. Such rapid digital modulation creates harmonics that could shift the laser carrier frequency, resulting in power fluctuations that create interference. A driver monitoring circuit to track and correct laser output power is being developed to prevent this. Such a system, allowing 1-gigabit data transmission rates, is close to development, according to Hirano.
- Process data collection systems, from Mitsubishi, that will collect data from many sensors in a loop-type fiber optic system. Strong signals will be needed for this all-optical approach, so a novel device is being developed in which beams from many individual lasers are combined into a single powerful beam. To keep all emissions at the same frequency, a phase-locked laser is being developed. So far, beams from five lasers have been combined, producing a total output of over 100 milliwatts.
- Wavelength-controlled laser diodes for process control, from Toshiba, useful in wavelength-division multiplexing (WDM). Several distributed feedback lasers will be combined on one chip, each emitting a different frequency. Each beam can carry independent signals. So far, five have been built on a chip, says Hirano. Demultiplexing is done with gratings spaced to separate beams by wavelength.

Optoelectronic integrated circuits, or OEICs, are a major goal of the national laboratory. Currently, optical transmissions must be converted to electronic signals for such operations as filtering, switching, and multiplexing. Intensive work is going on in laboratories around the world to develop alternatives—particularly optical devices, such as lithium niobate crystals, with waveguides on their surfaces for guiding light beams while performing such operations. But Hirano feels that combined optical-electronic integrated devices offer greater potential than the purely optical approach. "This may be suitable for some special functions, such as spectrum analyzers, but the interactions between photons are very small, so electrons will be needed for switching," he says. Similarly, he has doubts about current efforts, primarily in the U.S., to develop optical bistable devices for building digital optical computers.

The national laboratory has had to develop new processes for fabricating OEICs. The material chosen is gallium arsenide (GaAs). It has been used for both semiconductor lasers and electronics, and thus considerable knowledge exists. In fact, waveguides can also be fabricated on a GaAs chip, and coherent transmission is possible by using a laser in combination with a phase shifter, Hirano explains. Controlling polarization is critical to many guided wave-type devices. Later, Hirano says, his laboratory will look into other materials, such as indium phosphide, which produce longer-wavelength light (1.3 versus 0.85 microns) suitable for longer-range transmission.

Defect-free crystalline gallium arsenide wafers are needed as starting material. Thin layers of gallium arsenide and gallium aluminum arsenide (GaAlAs) are deposited on this substrate epitaxially (following the same crystalline structure).

In crystallizing gallium arsenide from a melt, an applied magnetic field suppresses convection within the molten material. Once a rod is cooled, it is sliced into wafers that, hopefully, are defect-free. If they're not, treatment with indium and silicon is used to "heal" them. Defect-free gallium arsenide wafers four inches in diameter are being supplied by this lab to Japanese semiconductor companies working on high electron mobility transistors (HEMTs), says Hirano, as well as to optoelectric groups.

Maskless ion implantation is used for doping. A 0.1-micron focused ion beam deflected with an electric field injects dopants into the surface. A combination of molecular-beam epitaxy (MBE) and metal-organic chemical vapor deposition (MOCVD) is used to build up thin layers on a gallium arsenide substrate. A process called reactive ion beam etching (RIBE), using chlorine, is being developed for etching the chips. Physical etching is done with chlorine ions accelerated in an electric field (an electron cyclotron resonance technique), and a chlorine radical is used for chemical etching. This dry process produces a good profile, where the unfocused ion beam previously used tended to undercut resist masks. Wafers are moved from station to station within linked vacuum chambers while these processes are performed in sequence.

In another project, three special types of glass fibers are under development: a bundle of 250,000 fibers that transmits an image directly, an infrared-type fiber for use as a temperature sensor, and a metal-coated fiber for use in high- or low-temperature atmospheres.

Fundamental studies of materials and surfaces are also done by the national lab. For example, impurities such as silicon, sulfur, or zinc in gallium arsenide crystals are investigated using secondary ion mask spectrometry

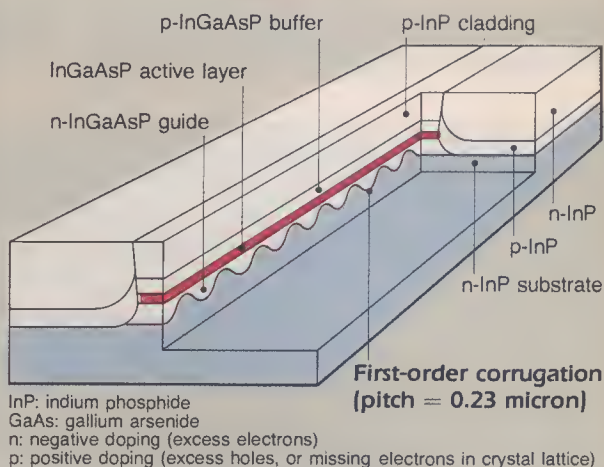
(SIMS). A transmission electron microscope provides 10-nanometer resolution, good enough to probe dislocations, crystal defects, impurities, and interfaces.

The support of the national lab does not prevent individual companies from pursuing their own proprietary developments. In Atsugi, Sony's Toshiyuki Yamada, general manager for systems LSI (large-scale integration) projects in the semiconductor group, says his company is now making laser diodes with an MOCVD process. Using trimethyl gallium arsine gas and a heated gallium arsenide substrate, Sony achieves more uniform epitaxy than with conventional processes, he says. Hitachi is using MOCVD for a multiquantum well laser that puts out 50 milliwatts at 0.78 micron. It contains seven GaAs well layers only 3 nanometers thick and six GaAlAs barrier layers of 5 nm. These devices can replace gas lasers in laser printers and optical disc file systems.

At Fujitsu in Kawasaki, a wide range of optical systems and devices are on exhibit, including a cutaway of an optical repeater for planned undersea cables that meets 25-year life tests. There are two transmitters (indium-gallium-arsenide-phosphide laser diodes) for redundancy and a germanium avalanche photodiode detector in each system, and three systems in each repeater, according to Takakiyo Nakagami, deputy manager of the optoelectronics systems lab. "Only Fujitsu and NEC are supplying submarine systems for NTT [the domestic telephone company] and KDD [Japan's international carrier]," he explains. Hitachi will supply AT&T, says Nakagami; the U.S. firm plans more standby lasers in its undersea optical repeaters.

Fujitsu's exhibit demonstrates how one vertically integrated company can make all the components going into entire systems: laser diode emitters, detectors, switches, fiber optic cables, and optical connectors. Fujitsu offers optical links for 6, 16, and 32 Mb/sec, and will have over 100 installations by the end of this year, says Nakagami. These include "data gathering for factories, office automation, some buildings, and university campuses for teaching," he adds. An example is an optical local-area network that has been installed by Fujitsu in Kawasaki Steel's Chiba Works. Data and voice signals are carried on cables consisting of 8 to 24 fibers capable of transmission speeds of up to 32 megabits per second. The system links more than 1000 on-line terminals and 2000 voice lines connecting over

Distributed feedback laser



Optical spectrum is narrowed for stable single-mode transmission in this Hitachi grating-type laser.

30 factories at the Chiba site. Current optical links carry voice, data, and still pictures or graphics, but not video.

Recently, Fujitsu introduced optical fibers in the U.S. capable of carrying 810 megabits/second on a single pair—about double the capacity of fibers previously available.

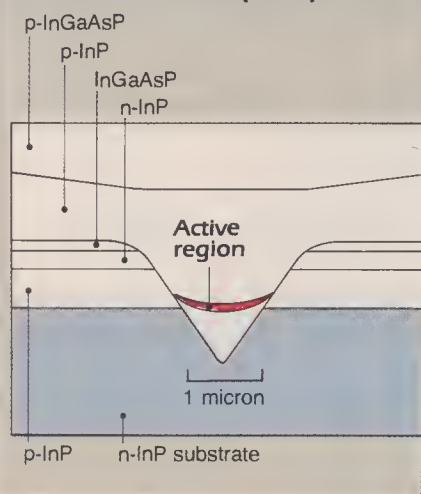
Although devices are beginning to be integrated on the same chip, the final target for Fujitsu's complete monolithic optical switch remains far off, admits Nakagami. Such switches could handle channels for optical CATV or local-area networks, or perhaps link many processors in a large computer system. Working with Fujitsu's Atsugi laboratories, the optical group has designed a single gallium arsenide chip that includes a transmitter laser diode with four FETs (field-effect transistors), a PIN photodiode with six FETs, and several Schottky diodes. Since the devices are for multimode transmission, range is limited to a few kilometers. But Nakagami believes Fujitsu is the first to put all of this into a single package, connected to a fiber.

The market for integrated optical devices is expected to be huge, according to Takahiko Misugi, director of the Fujitsu research laboratory in Atsugi. They will be used "even for communicating from home to home eventually." Most research done at Japanese laboratories tends to be aimed at solving potential problems in future practical devices. At the Electrotechnical Laboratory in Tsukuba, for example, researchers have spent over 10 years struggling to design a semiconductor laser scheme to both read and write on a videodisc, thus making a more compact, lower-cost record/playback unit for data storage. The main problem with the device, called a SCOOP (for self-coupled optical pickup), has been that light reflected back to the laser stimulates excessive lasing action through self-coupling. The latest of a sequence of possible solutions is an anti-reflective plate (now a thin antireflective coating on a lens) that blocks a quarter of the light beam, thus disrupting the coherence of the reflected beam.

Now that they have caught up or even taken the lead in many frontier technologies, the Japanese are beginning to emphasize basic as well as applied research. It will be some years before the full effects are evident, but if progress in optoelectronics is indicative, remarkable advances can be expected. □

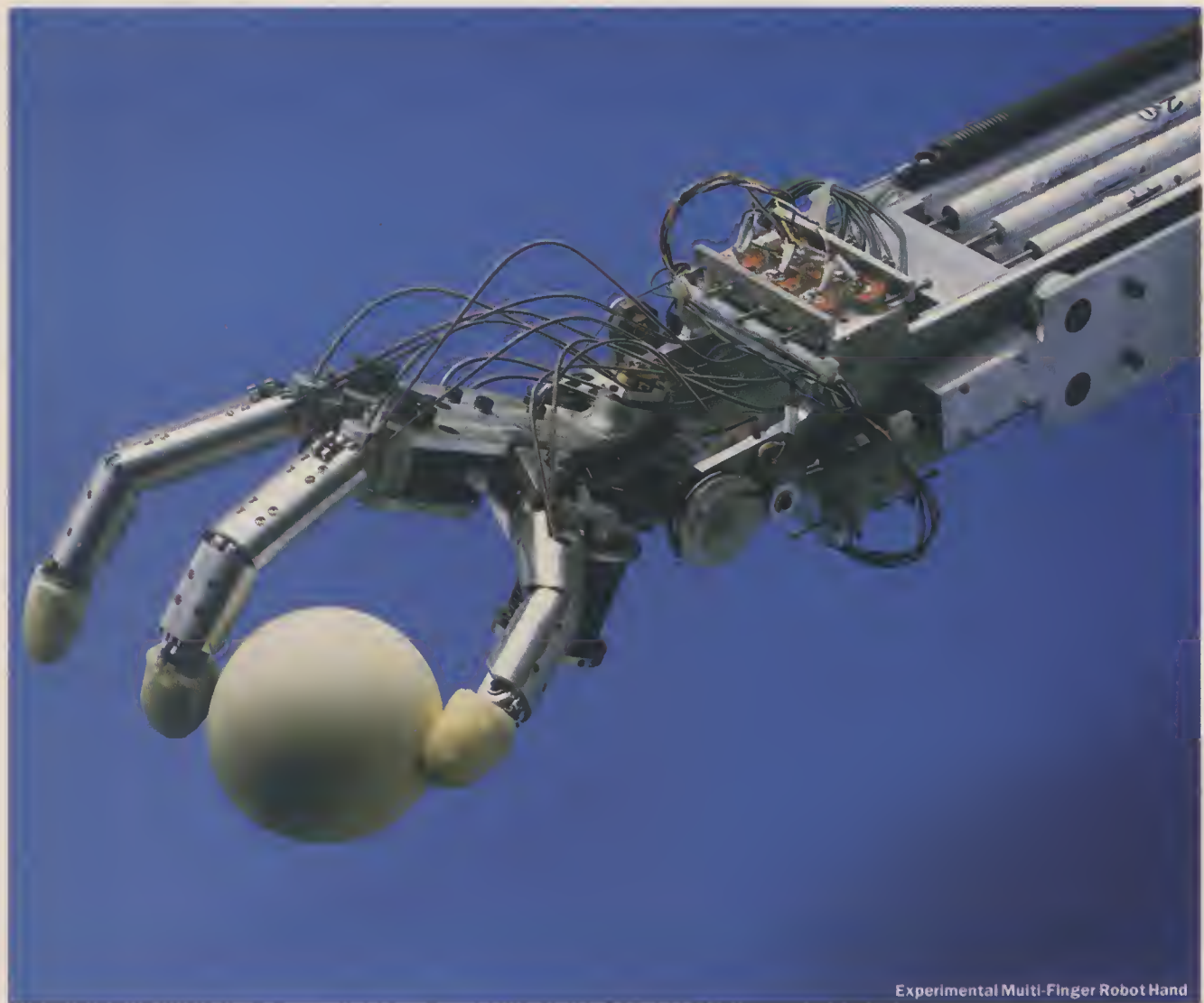
Buried-crescent laser diode developed by Fujitsu emits a 1.3-micron beam that can be used for long-distance, high-data-rate transmission over monomode optical fiber systems.

V-grooved substrate buried heterostructure (VSB) laser



HITACHI TECHNOLOGY '85

Humanizing High Technology



Experimental Multi-Finger Robot Hand

Robot hands so deft they can handle a ball, intelligent communications systems, machines that see—these are but a few of the technological advances that promise to carry industry to a new level of productivity in the coming decade. But that will happen only if the interface—the meeting-point—between man and machine is made as friendly as possible. That's why Hitachi is dedicating its huge R&D effort to creating machines that are easy to master. We believe this commitment to humanizing technology will increase the efficiency of everyone.

HITACHI TECHNOLOGY '85

Hitachi shows life-enhancing technology at Tsukuba Expo '85.



Hitachi Group Pavilion

Visitors to the Expo '85 science and technology exposition in Tsukuba, Japan, can see a striking demonstration of that dedication. The theme of Expo '85, which is being held through Sept. 16, 1985, is "Dwellings and Surroundings—Science and Technology for Man at Home." In keeping with that theme, Hitachi has erected a futuristic pavilion housing exhibits that stress the human side of industrial technology.



Electronic Information Corner

At the Robot Art Corner on the pavilion's first floor, for example, three of Hitachi's sophisticated industrial robots, accompanied by lively music, carve blocks of ice into shapes suggested by visitors. This demonstrates in an artistic task the extraordinary dexterity that enables them to handle difficult production tasks on the factory floor. Nearby, an experimental robot waves its arms at visitors, employing advanced muscle-like rubber actuators that may someday be used to increase the dexterity of factory robots still further while reducing their weight.

In another corner, an advanced information system displays weather, news, sports, and travel information on television screens—instantaneously at a visitor's request. Other advanced technologies on exhibit include an

electronic photographic system consisting of a high-definition television system that produces images of photographic sharpness on a screen and a high-resolution color printer that faithfully reproduces the images on paper.

The Hitachi Group pavilion at Expo '85 is a fascinating and imaginative illustration of the many ways in which technology adapted to human needs can make life easier and more rewarding for everyone. But it barely skims the surface when it comes to portraying the vast range of Hitachi's business-oriented high technology products and services, many of which are available in the U.S. through Hitachi's American subsidiary, Hitachi America, Ltd. Here is how some of those products can boost the efficiency of your company.

FACTORY AUTOMATION

Because they can do many production tasks that previously required custom-built machinery and can easily adapt to new tasks, programmable robots are proliferating rapidly in factories. Hitachi's line of high-performance robots feature technological advances that make them especially suitable for factory applications. For example, Hitachi robots employ small but powerful electric motors to drive their joints instead of the bulky hydraulic or pneumatic actuators used on other factory robots. As a result, they are smaller, lighter, defter, and faster. And Hitachi's robots can remember and repeat tasks taught them by an operator. This eliminates the need to learn a complicated programming language. Indeed, an operator can learn how to train a Hitachi



Ice-Sculpting M6060 Process Robot

robot to do any task in less than an hour. The Hitachi method of job level and program level programming has gained worldwide acceptance for its ease of understanding and interfacing with plant personnel.

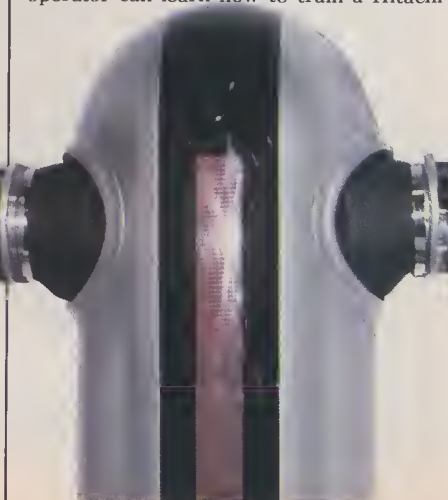
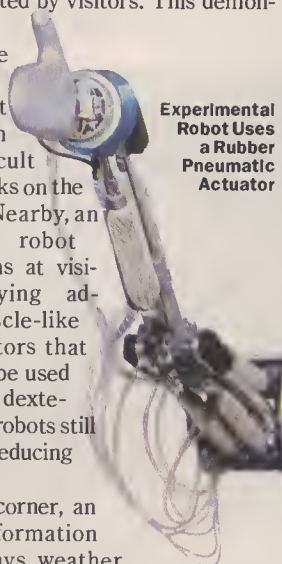
M6060 Process Robot

Hitachi's robots can handle a wide range of automated assembly operations, including picking, placing and inserting components, greasing mechanisms, tightening screws, and palletizing completed assemblies. For example, our versatile M6060 process robot, which can be seen sculpting ice at the Tsukuba Expo '85, is particularly adept at handling large or heavy parts thanks to its use of powerful electric motors and incorporation of an arm having six degrees of freedom. The process robot has a new flexible wrist that enables it to perform intricate tasks or follow complex contours.

A4010H Assembly Robot

The model A4010H robot, on the other hand, is ideal for electro-mechanical or electronic assembly because of its low cost, small size, speed, and positioning accuracy. The

Experimental Robot Uses a Rubber Pneumatic Actuator



HITACHI TECHNOLOGY '85

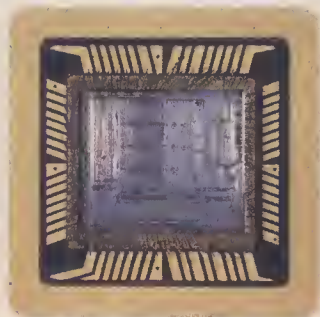


A4010H Assembly Robot

unit occupies only about 4 square feet of floor space and consumes only 300 watts of power. Its high speed and positioning repeatability permit quick and easy palletizing work where there are many positioning points.

IP Series Image Processing System

Our newest factory automation product is the IP Series image processing system. Intended to handle an assortment of industrial machine vision applications, the IP Series system can process both color and monochrome images having as many as 256



ISP (Image Signal Processor)

shades of gray at extremely high rates—one picture element every 167 nanoseconds. At the system's heart is an image signal processor (ISP) on a chip—a Hitachi innovation that accounts for its high speed. Preprogrammed to perform many basic image processing and recognition functions, the system comes with an interactive picture evaluation software package that speeds applications software development.

HV/R-1 Vision System

The application of robots to assembly tasks can be greatly simplified by another advanced Hitachi product, the model HV/R-1

vision system. Most robots used in assembly today are blind. As a result, special fixturing systems are required to ensure that parts are supplied to the robot at a specified position and in a specified orientation one by one. Because it enables a robot to recognize the shape of a part and detect its position and orientation, the HV/R-1 vision system eliminates the need for complex, and expensive, parts positioning systems. All that is required is a simple parts transfer device, such as a conveyor belt. And like Hitachi's robots, the HV/R-1 requires no programming: the system automatically recognizes parts previously shown it by an operator.



HV/R-1 Vision System

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features and improved reliability while maintaining the system's attractive price. It will help you to control costs, generate profits and speed communications vital to your business.

For example, the system helps control costs with new record keeping and long distance routing technology. The system's CommCenter generates detailed reports down to the station level that enable you to identify abuse and optimize trunking. The system can also help your business generate profits through its client billback and resale tenant services.

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With computers proliferating in the office, many companies are coming to rely on the phone system to enable computers as well as people to communicate. The DX series supports this trend, currently allowing computers to exchange information at rates as high as 9600 bits per second—more than adequate for many office data communications applications.

For small companies, Hitachi offers the single-cabinet EDX system, which has a capacity of more than 400 stations. It delivers all the advanced features of a larger system while eliminating the cost of unnecessary station expansion. Also available for hotels is Hitachi's WELCOMM™—a unique system that combines telephone and front desk functions to provide profitable resale and enhance guest services.

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2990 Gateway Drive, Suite 1000,
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DX Series Business Communications System

HITACHI TECHNOLOGY '85

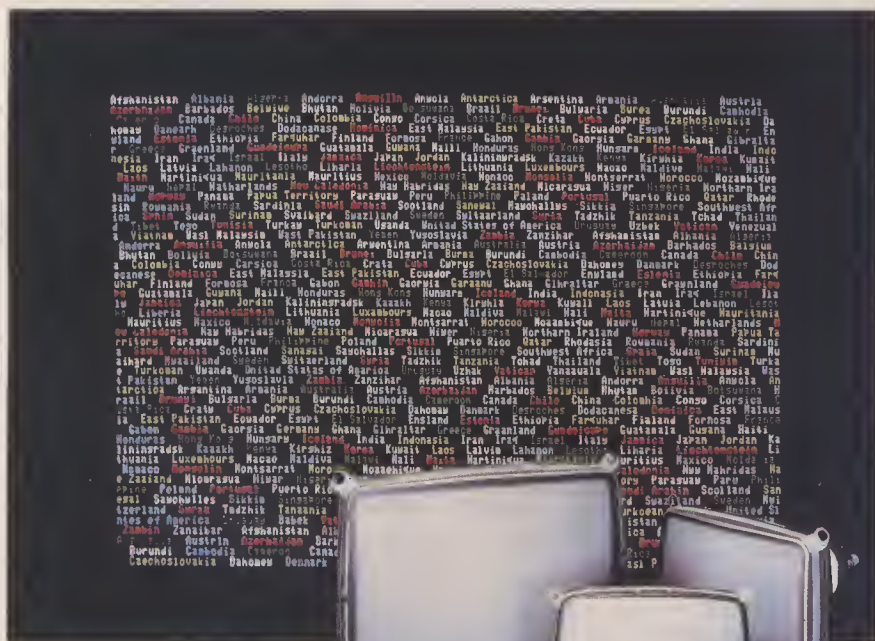
DISPLAY TECHNOLOGY

Display Tube

Display devices play a key role in simplifying the use of technology by enabling people to communicate with machines through text and images. Hitachi's extensive line of color cathode-ray tube (CRT) displays features a new high-resolution electron gun that produces extremely crisp graphical and textual images. A black-matrix screen also contributes to the clarity and brilliance of the images produced by Hitachi's color units. Because of their reliability and ability to produce extremely sharp images, Hitachi dis-

Manufactured to exacting standards to assure reliability, Hitachi LCDs produce clear, sharp textual or graphical images with virtually no pattern deformation. And they are available in a wide assortment of shapes and sizes to suit a multitude of applications. To simplify their integration into end products, Hitachi also offers LCD modules which come with low-power CMOS chips that integrate all the circuitry required for their operation.

At the top of our LCD line is the model LM225. This high-resolution module, whose screen measures 9.4 by 4 inches, can display a dot-matrix comprising as many as 200 rows of 640 dots each, thereby enabling the creation of highly readable alphanumeric characters and crisp graphic images. Drawing only 110 milliwatts of power, the LM225 module includes the liquid-crystal



Display Tubes

plays are widely used in computer terminals, CAD/CAM systems, office systems and as TV monitors both in the U.S. and Japan.

Liquid Crystal Display

Hitachi also offers a full line-up of liquid crystal displays (LCDs) that produce images by selectively reflecting ambient light. Because they do not need to generate light to produce a display, LCDs consume very little power and are extremely compact, making them ideal for portable computers, telephones, and other products where power consumption or small size is paramount.

display, integrated driver circuit, printed circuit board and other related components. To simplify integration of the LM225 and other Hitachi LCD modules into portable computers and other systems, we also offer an HD61830 controller chip that handles the creation of alphanumeric characters and graphics.

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HITACHI®

Building up when the chips are down

I**TAMI**—Japanese executives, asked why they are continuing to make large capital investments in semiconductor plants and equipment when sales are slumping and prices falling, explain that market share, not short-term profits, guides their investments. Virtually every semiconductor company in Japan is expanding. They are adding product lines, pushing research on future technologies, and formulating plans to further strengthen their positions in memories while gaining larger shares of other chip markets. Japan's capital investment in semiconductor equipment topped \$4 billion last year (bigger than in the automobile industry), and major producers plan to come close to that level this year.

The sharp decline in the semiconductor market during the first half was just a temporary lull in a rising market, believes Hisao Oka, general manager of Mitsubishi Electric's LSI (Large-Scale Integration) R&D Laboratories in Itami (near Osaka). "The semiconductor market will gradually recover and be back up again by the end of this year," he predicts. Cost/performance gains in chip technology steadily open up applications in new fields. Broader usage cuts market volatility, Oka points out. In the 1960s, the semiconductor market fluctuated 30–40%, versus only 10–20% in the 1970s.

World sales of Japanese semiconductors grew 38% last year, helping to provide capital for expansion. This was due largely to a booming market for 256K dynamic random-access memories (DRAMs). Japanese vendors, led by NEC and Hitachi, captured over 90% of the world market (HIGH TECHNOLOGY, June 1985, p. 37). Now at least six vendors in Japan—Toshiba, NEC, Hitachi, Fujitsu, Mitsubishi, and Matsushita—are promising samples of megabit RAMs this year.

Toshiba has also moved to expand its markets with a 256K static RAM (SRAM) and a new lower-cost process to produce EEPROMs (electrically erasable programmable read-only memories). Static RAMs do not require the constant refreshing necessary in dynamic RAMs, thus saving considerable power, and they are easier to interface to other circuitry. Power savings will be particularly impor-

tant as the portable computer market grows. But with six transistors—instead of a single transistor and a capacitor, as in a DRAM cell—256K SRAMs are hard to shrink onto economically sized chips. Yet NEC, Hitachi, and Mitsubishi all say they will follow Toshiba's lead into the market.

U.S. manufacturers hold most of the market for EEPROMs, which are generally used to store fixed data that must occasionally be updated, such as the control logic in a robot. Now Fujio Masuoka, Toshiba's manager of memory design, claims he has developed a process that dramatically lowers production costs. By using a triple-polysilicon process, cell size has been reduced enough to pack 256K bits onto a chip. It's called a flash EEPROM, because bits are electrically erased all at once in about a tenth of a second, compared to about 15 minutes using ultraviolet light in conventional erasable PROMs (EPROMs)—devices used to store relatively fixed control data, as in copiers. As prices for 256K EEPROM chips fall from tens of dollars down to the \$2–\$3 range, they should take over the much larger EPROM market, estimated at \$1.2 billion annually worldwide, Masuoka believes. The new EEPROMs are so easy to program they might even displace masked ROMs, used in such applications as video games, according to Toshiba. World masked ROM sales are about \$600 million.

Aside from the quest for market share, there's another reason for the rapid progress in Japanese semiconductors. Most suppliers are divisions of large, vertically integrated conglomerates. The systems builders constantly push their chipmaking affiliates to come up with designs that will give them a marketing edge. These internal needs help drive chip technology, and provide a rationale at the corporate level for making large investments in processing equipment for advanced semiconductors. In fact, the national goal of world leadership in computers led to a major effort to upgrade Japanese integrated circuit technology from 1976 to '79. This VLSI (very-large-scale integration) project, backed by \$120 million in loans repayable from future profits, was perhaps Japan's most successful national industrial effort. Today collaboration at a national level has faded; semiconductor vendors are fiercely competitive.

Top management's continuing commitment to advancing VLSI technology, even in a falling market, is well illustrated by the plans made for Mitsubishi Electric's labs in Itami. Two pilot lines will be built soon, one to make megabit DRAMs and the second one (next spring) to make 4-megabit DRAMs. The megabit DRAMs will pack 2.2 million devices on a 60-mm² surface by using 1.2-micron design rules. On these devices the titanium silicide gate insulator, which insulates a metal gate from the chip surface, will be only 100 angstroms thick, instead of 250 Å for 256K DRAMs. The high density of the 4-Mbit DRAMs will require a step down to 3.3 or even 3.0 volts rather than the traditional 5-volt supply. Some 5 million devices will be packed onto 90-mm chips using 0.8-micron design rules. Gate electrodes will be made of a refractory metal rather than a metal silicide. The 4-Mbit pilot line will include a Class 1 clean room.

Masks have already been designed for 4-Mbit DRAMs, using molybdenum silicide, rather than the usual chrome,

by Robert Haavind

to provide better adhesion, sharper and more uniform edges, and less undercutting during etching (raising the resistance values of such fine lines). Since Mitsubishi is not a maskmaker, it is licensing this submicron mask technology. Five companies—four Japanese and one U.S.—have already visited Itami for this purpose, says Oka.

A new etching process for submicron chips has also been developed. Called electron-cyclotron resonance (ECR) plasma etching, it improves on a previous plasma etching process by eliminating a grid used to accelerate ions onto the wafer. The grids were a potential source of contamination. In the new approach a beam excited to microwave frequencies is guided to the wafer through an electromagnetic field. By raising the field frequency until it resonates with the microwave frequencies of the beam, ions are accelerated onto the wafer without a grid. Because the grid partially blocked the beam, removing it also allows etching at lower energies, thus doing less damage to the surface.

These pilot lines will be capable of making all kinds of semiconductor devices, not just memories. And Oka believes that systems companies all over the world will want to take advantage of this advanced production technology for application-specific integrated circuits (ASICs) as well as for more standardized devices.

Despite such plans, some observers believe that even though the Japanese chipmakers have gained a strong lead in the production-oriented DRAM market, they will not be able to compete as well in other VLSI sectors, such as logic chips, microprocessors, and linear circuits. Software-dependent design tools are needed to design large arrays of circuitry onto single chips for particular applications, and Japanese companies have been weak in software development. Furthermore, close coordination between systems designers and chip fabricators is essential for VLSI chips, and this may prove difficult for Japanese vendors to establish on a global scale.

Although they agree these are formidable obstacles, Japanese executives say they still intend to compete strongly across the VLSI market spectrum. Design centers have been set up in high technology regions throughout the U.S., Europe, and Japan. These networks will be expanded, with the



LOU JONES

In Fujitsu's new master slice, tailorable logic/memory cells will carpet the chip, says lab director Takahiko Misugi.

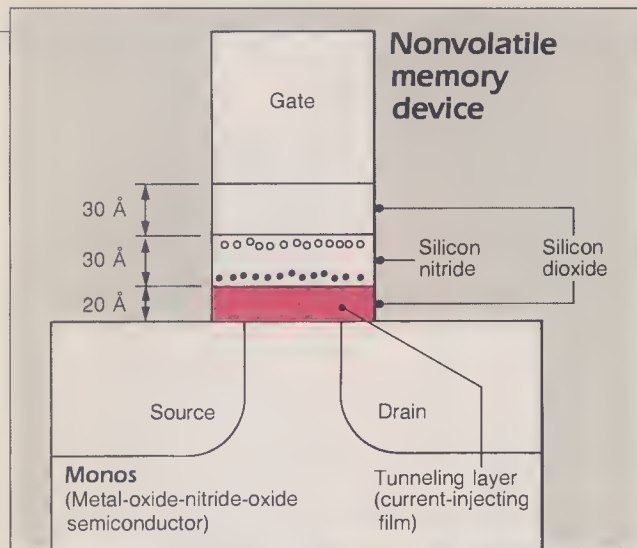
growing number of design centers linked to large computers at design headquarters in Japan. One factor that has slowed this build-up in design centers, explains Tadao Higashi, general manager of Oki Electric's Integrated Circuit Division in Tokyo, is the huge demand for DRAMs. "We did not have the capacity we needed to expand our gate array business," he says. The current widespread expansion of semiconductor facilities in Japan will alleviate that problem.

Fujitsu has already established itself as a world leader in gate arrays, the simplest form of tailorable semicustom chips. Now it is developing technology to extend its capabilities. A new master slice concept, based on an 8-transistor cell rather than the 4-transistor cell used previously, allows any cell to be configured as either memory or logic.

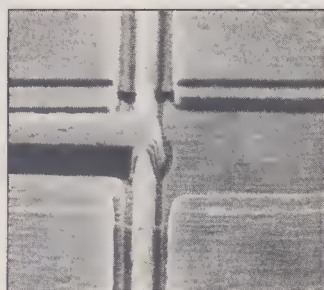
"We will carpet the chip with these cells," explains Takahiko Misugi, di-



Hitachi's Kokubunji lab has developed design aids for 3-D integrated circuits.



Above: Nonvolatile MONOS memory element to allow microprogramming of ultra-large-scale integrated (ULSI) chips is being developed at Tsukuba's Electro Technical Laboratory. Right: Hitachi's high electron mobility transistor (HEMT) has a gate length of 0.5 micron.



rector of Fujitsu's laboratories in Atsugi. Normally half of the chip area would be required for connection patterns. The new master slice will have a layer of silicon dioxide over the active devices, and connections will be deposited over this layer, thus essentially doubling circuit density. This approach, using a 3-micron CMOS (complementary metal-oxide-semiconductor) process, will produce 6×6 -mm chips at very high yield, claims Misugi.

Misugi even hints that he sees this master slice approach as a possible route to wafer-scale integration, in which entire systems or large subsystems are all made on a single wafer rather than on separate chips. "Physical yield must be controlled, and the method used to make connections will be the key," he says.

Other Japanese competitors in the global market for semicustom chips include NEC, Hitachi, Toshiba, Mitsubishi, and Oki. Like Fujitsu, they are expanding their worldwide design center networks. Mitsubishi, for example, has design centers for gate arrays near San Francisco and in North Carolina in the U.S., and in Kamakura and Itami in Japan. Several more will be opened, and linked to design headquarters in Itami. A symbolic layout system has been devised for large-capacity VLSI chips, to reduce design time.

Even though a slump in the personal computer market early this year caused a sharp drop in Japan's major market—dynamic RAMs—a new boom market for this technology may be coming soon, suggests Oki's Higashi, who also heads the company's VLSI R&D Center in Tokao.

"All the TV manufacturers are eager to get 2-megabit DRAMs for use as frame stores," Higashi explains. In advanced digital television sets, a single digitized TV frame is held in memory for processing. Ghosts or snow on the screen can be eliminated, a full frame rather than two interlaced fields can be displayed to sharpen an image, and in some models an alternate channel can be displayed in an inset window on the screen. Such TVs use a set of chips to digitize the image, plus eight 256K DRAMs to store a frame.

The memory chips could be replaced by a single 2 megabit DRAM. Two megabits is about the minimum storage needed, because a color TV picture requires roughly 250,000 picture elements, or pixels (500 lines of 500 pixels), with resolution of eight bits each.

Digital imaging technology could find many applications in the home entertainment system of the future, says Oki's Higashi. He also sees a large market in memory chips for many types of image processing functions in graphics systems, such as CAD/CAM applications.

The shift to digitization of TV pictures, sound recordings, and voice transmission, is spurring efforts by Japanese companies to improve the performance of analog-to-digital (A/D) and digital-to-analog (D/A) converters. Even though transmission and processing of digital signals is increasing, the original images or sound inputs as well as the outputs to humans are analog. This will mean strong growth in the use of converter circuitry, according to Minoru Nagata, senior chief researcher at Hitachi's Central Research Laboratory in Kokubunji. CMOS is the favored technology for future converters because of its low cost, high density, and low power consumption. Unfortunately, frequency response, noise performance, and dc offset voltage are not as good as in bipolar chips.

For digitizing video, high-frequency conversion will be essential—at least 20 MHz for color TV. Future high-definition TV will require 50–100 MHz for 1000×1000 pixels, and 400 MHz for 2000×2000 pixels, all with 8-bit precision. To boost speed, channel lengths in devices will be cut down to 1 micron, intensifying CMOS problems, Nagata says. As a result, a number of innovative circuit schemes are being devised by Hitachi engineers to overcome these shortcomings.

Sony is another company that sees opportunities in the growth of digital processing, and is planning to boost sales of semiconductors outside the company, according to Toshiyuki Yamada, general manager for systems LSI at the Atsugi plant. A/D and D/A converters appear to be a strong emerging market for Sony's high-speed bipolar emitter-coupled logic (ECL) technology. Many special-function chips for compact disc players and similar consumer equipment will be sold outside the company. Sony also hopes to boost sales of the charge-coupled devices (CCDs) that it makes for video cameras.

One market where the Japanese have had little success is microprocessors. These chips are much more complex than memories, and U.S. manufacturers have a big lead. Families of chips like Motorola's 68000 and Intel's 8086-8088 and their follow-ons have become worldwide standards. The shift to 32-bit microprocessors from the 16-bit versions now widely used may give some Japanese companies an opportunity to move into the market. But the need for compatibility constrains them from being very innovative. Some Japanese companies are making licensing agreements with U.S. firms to produce popular microprocessors in Japan, sometimes in enhanced versions.

NEC has made the strongest foray into the 16-bit arena with its CMOS V-20 and V-30. But it has run into legal problems with Intel, which claims the microcode in these chips is too close to that in its own 8086-8088 series. Although the V series is compatible with the Intel chips, it does have some differences. A dual-bus architecture allows the NEC chips to run faster in some cases, particularly for real-time applications. Further enhancements are planned, including 32-bit chips—the V-60 in 1986 and V-70 in 1987. Second sourcing of these chips, unusual in Japan, will make the V series available from Sony as well as from

Zilog and possibly other U.S. vendors.

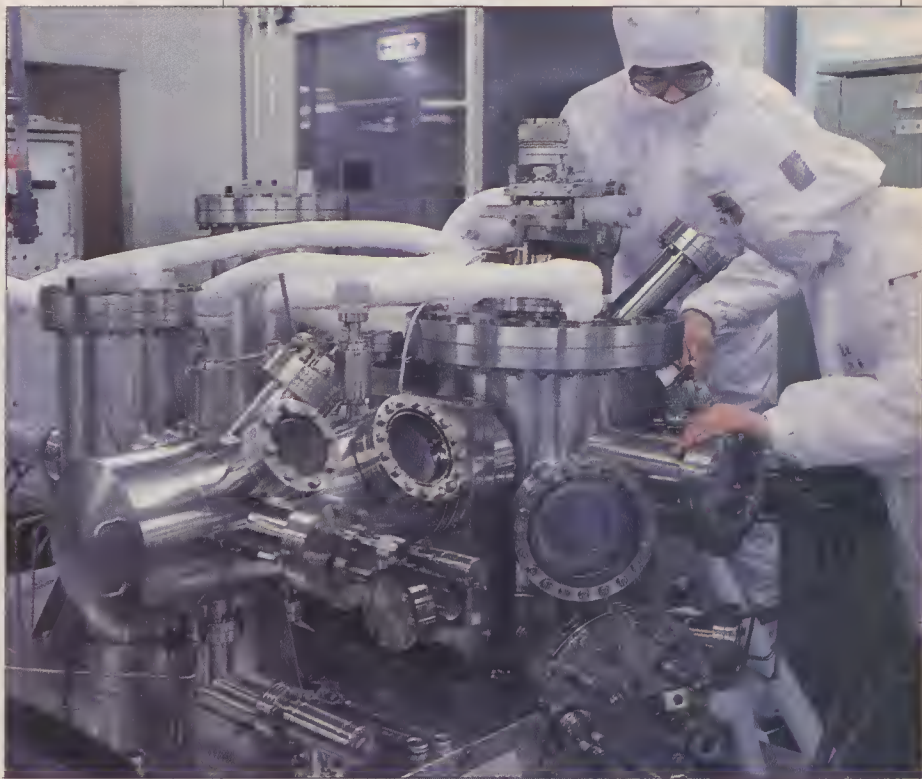
At the National Electrotechnical Laboratory in Tsukuba, Yutaka Hayashi, head of the semiconductor device section, explains that his lab's mission is to look far ahead, beyond what individual companies will be developing on their own. When chips reach 0.2- to 0.8-micron line widths in the ULSI (ultra-large-scale integration) era, a flexible architecture will be needed to produce universal chips suitable for a wide variety of applications. The same chip will hold some type of tailorable logic compatible with the devices in a 64-megabit memory.

One approach being investigated is the use of nonvolatile read-only memory (in which data are retained even when power is off) that can be microprogrammed for individual applications. As circuit density increases, voltages must be lowered to reduce heat and to avoid punch-through avalanche effects. At submicron dimensions, a 5-volt supply would look like 50 volts at 3 microns, Hayashi says. A 1-volt supply is more likely at this density.

A unique three-layer gate insulator structure is being developed to accomplish the nonvolatile memory function. On top of the channel in the device is a 20-angstrom tunneling layer of silicon dioxide. Stacked on this are 30-Å layers of silicon nitride and then silicon dioxide. The tunneling layer acts as a current injection film for writing a charge into the device, but it also prevents leakage of charge back to the nitride from the silicon surface. A programming input of about 4 volts would be used to write data into these nonvolatile memory/logic devices.

Several laboratories are actively developing three-dimensional integrated circuit structures. Hitachi has even developed software to enable designers to work with 3-D circuit structures on an engineering workstation. Mitsubishi has been working on a five-layer silicon-on-insulator (SOI) image processor. A laser beam is used to turn each successive layer of silicon from a polycrystalline to a single-crystal structure suitable for making devices. Light would strike a top image sensor layer, and the image would be digitized by the second layer. Image processing would be done by the next two layers, which would contain a RAM and a central processor. The fifth layer would convert the results back from a digital to an analog signal.

As with many other products in Japan's huge diversified companies, design software and even engineering workstations have been developed to meet internal needs. At Kyoto's Omron Tateisi Electronics, where timesharing systems were overloaded, head engineer Tatsuro Ichihara assigned two young engineers to develop a workstation to speed Omron's internal design work. The workstation is based on the Motorola 68000, and uses the Unix operating system. Ichihara decided that the resulting system had commercial potential, although he had no sense of how well it stacked up against competitive equipment, particularly from the U.S. Then an article in *Byte* magazine tabularized the performance of a wide range of Unix-based workstations. He was startled to discover that the Omron system



Production techniques for gallium arsenide integrated circuits are being developed at Mitsubishi's Itami laboratories.

outperformed all the systems in almost every category.

Two fundamental decisions made by the designers speeded up the system, Ichihara found. Other workstations had control logic that went through many levels of gates, creating delays in complex processing. In the Omron approach the microcontrol is done with single-level random logic, so delays are minimized. In addition, several buses are used to speed the movement of data, including a dedicated bus between memory and central processor (this approach is taken in some other workstations as well).

The Supermate workstation was subsequently put on the market in Japan. It will run programs written for both Unix V and Berkeley 4.2, according to Ichihara. It might go onto the market in the U.S. next year, he says.

Almost every Japanese semiconductor company is actively working on production processes for gallium arsenide integrated circuits, which are being demanded by the Japanese computer companies for future high-speed systems, particularly supercomputers. At Mitsubishi's Itami labs an additional pilot line will be set up for gallium arsenide chips.

Development of superconducting Josephson junction circuits is also very active at several companies. A serious limitation of these circuits is that they are two-terminal devices, and in the past this kind of technology has always lost out to more versatile three-terminal devices. Recently Hitachi developed a three-terminal superconducting transistor, but other Japanese companies expressed doubt that this particular design will prove viable.

In semiconductor technology, the Japanese obviously take a back seat to no one, and if the next ten years in this most fundamental of high technologies show the kind of progress accomplished in the last decade, the results will be awesome. □

Marching into the New Stone Age

KYOTO—If you visit the Tokyo office of Kyocera, the Kyoto-based ceramics company, director Ryusho Nagai will probably trot out one of the company's latest products—a 12-inch sushi knife with an unusual gray luster. Barely touching the blade to a piece of stationery, Nagai quickly reduces the paper to a pile of confetti. "We sometimes worry about criminals getting hold of this," he says, half in jest. "You can walk right through a metal detector with it."

The knife is fashioned not of steel but of zirconia (zirconium oxide), and is just one example of what Nagai calls "the New Stone Age"—Japan's massive commitment, on the part of both government and private industry, to developing new ceramic materials, processes, and applications. Like the ceramics used for such familiar items as table china, bathroom fixtures, and decorative glassware, the new materials are based primarily on silica and other earth-derived elements and compounds. Unlike their predecessors, however, the new formulas (sometimes called advanced ceramics) exhibit an unusual array of properties. Many of them are stronger than steel, but at only about half the weight. They also possess unique electrical and/or heat transfer properties, and are highly corrosion- and shock-resistant.

These properties make many of the advanced ceramics prime candidates for such diverse applications as micro-electronics, biomaterials, machine tools, bearings, valves and seals, solar cells, automobile engines—and, of course, sushi knives. And although the materials still face problems of manufacturing and customer acceptance, almost every major Japanese chemical processing company is carving out a market niche. "We think that in this country alone, total sales of the new ceramics will exceed \$9 billion in 1990," says Hideo Sugie, senior manager of Toshiba's new materials group in Tokyo. The 1984 figure was \$2.7 billion, he adds.

Toshiba claims to be a world pioneer in the technology of silicon nitride, one of the most promising of the new ceramics. The National Research Council in Washington, D.C., confirms that the company holds about a third of

Japan's nearly 400 patents in new ceramics technology. One result of this expertise was a joint venture with Koyo Seiko, a well-known Japanese bearings manufacturer: Early this year, the venture introduced a line of silicon nitride roller bearings for gas turbine engines and other types of machinery. The bearings not only are much lighter than steel bearings of comparable design but can operate at up to 800° C; most conventional steel bearings can't tolerate extended operating temperatures of 120° C.

It isn't surprising that Toshiba is also keen on silicon nitride's automotive use, a natural application in view of the material's strength, heat- and shock-resistance, and light weight. But the ceramic engine will take shape little by little, starting with components now under trial by several automakers—the diesel precombustion chamber, for example. "The rest of the '80s will be an important transition period for ceramic engine parts," says Sugie. "Soon we'll be seeing ceramic rotors, valves, and cylinder walls."

Other companies are also intrigued by advanced ceramics' structural, or "engineering," qualities. Asahi Glass (Tokyo), for example, started its engineering ceramics division in 1982 as an outgrowth of its long-standing business in glass and refractories (heat-resistant ceramics). Annual sales of the company's silicon nitride and silicon carbide products now come to only about \$2 million, according to Yukio Fukatsu, director of engineering ceramics development and marketing. But he expects sales to climb rapidly, partly through Asahi's pursuit of specialized industrial markets, such as valves and seals, and partly through its emphasis on technology licensing rather than product sales.

With a few exceptions such as artificial joints and bone replacements, Asahi is aiming at heavy industries like steel and chemicals—natural targets for ceramics' outstanding resistance to high temperatures and corrosive materials.

Two examples are the company's aluminum titanate (Lotec T) and zirconia (Lotec Z). Because of their very low thermal expansion coefficients, these materials are being promoted for use as tubes, insulators, catalyst carriers, and other applications in chemical production and metallurgy.

Among its many research projects, Asahi is developing a new class of ceramics based on zirconium boride. While Fukatsu declines to give many details about the material, he claims that its electrical conductivity is about the same as that of iron—a provocative new feature, since ceramics have long been used as electrical insulators. Moreover, the boride is twice as hard as alumina (aluminum oxide, a type of ceramic that may be useful where shock-resistance is not a priority), and under certain conditions operates at up to 2000° C. And while the extreme hardness of most advanced ceramics often presents serious machining problems, zirconium boride's high electrical conductivity is readily utilized in the finishing methods called electropolishing and electric discharge machining. Potential applications of the zirconium boride include cutting tools, dies and molds, and high-voltage electrodes.

by H. Garrett DeYoung



LOU JONES



Above: Advanced ceramics' unusual electrical properties, light weight, and corrosion and heat resistance make them promising alternatives to metal in electronics, machine tools, bearings, seals, and engine components. Left: At Asahi Glass, managing director Takahashi describes a forming process that improves ceramics' mechanical properties.

At Kyocera, it's hard to find any marketing or manufacturing area in which ceramics is not playing an important part. With 1984 sales of about \$1.1 billion, the company is considered one of Japan's most aggressive suppliers of optics, consumer and industrial electronics, household goods, synthetic jewelry, medical implants, and machine cutting tools—all of which use ceramic materials or processing technology.

Kyocera's electronics business includes a large array of

ceramic components (semiconductor packages and multi-layer capacitors, for example), as well as finished consumer items, such as the popular Radio Shack Model 100 portable personal computer. The company's Ceratip line of machine cutting tool tips is an important part of the industrial ceramics division, which scored some \$87 million in sales last year. Several of the tips are based on alumina, zirconia, and titania (titanium oxide); others in the Ceratip line are composed of extremely tough cermets—ceramics to which



Toshiba's Shimizu displays a ceramic part that may soon show up in turbochargers. "Customers are interested in these new materials," he says, "but they often need a lot of selling."

a small amount of metal has been added. (Titanium nitride and cobalt-bonded tungsten carbide are familiar examples.) And like Asahi and other ceramics researchers, Kyocera manufactures dental implants and artificial joints (Kyocera's are made of an alumina called Bioceram). Approximately a sixth of Japan's dentists have attended the company's implant seminars, according to Nagai, and the dental materials have been used successfully in more than 75,000 patients.

Kyocera is also targeting another potentially enormous application: automotive design. During the early 1980s, the company was among the first in Japan to demonstrate a customized three-cylinder diesel engine containing several ceramic parts. Not surprisingly, says Nagai, the domestic competition is fierce; it includes Toshiba, NGK Insulators (Nagoya), and NGK Spark Plug (Nagoya). Working through a joint venture with Cummins (Columbus, Ind.), NGK Insulators is reportedly focusing its automotive research on the use of zirconia. The company also supplies ceramic

oxygen sensors to Ford Motor Company. Research at NGK Spark Plug is based largely on the more shock-resistant silicon nitride.

While there is no shortage of promising ceramic materials, processing is still a major obstacle. Conventional manufacturing routes such as hot isostatic processing (in which the powdered ceramic is molded at temperatures of up to several thousand degrees C, under very high pressure) are burdened by almost prohibitive energy costs. And while many of the advanced ceramics are extraordinarily tough, brittleness remains a major drawback.

Asahi claims to have several approaches for solving many of these problems; for example, sintering processes for silicon nitride and silicon carbide may replace high-pressure forming of these materials in certain applications. (Sintering is a high-temperature, usually pressureless process that increases the strength of a ceramic by eliminating the tiny gaps between particles.) Another example is a process called reaction bonding—licensed by Asahi from British Nuclear Fuels—which closely binds silicon atoms to each other, then adds atoms of nitrogen to form silicon nitride. Marketed under the name Refel, the extremely dense and gas-impermeable ceramic is being promoted for use in industrial heat exchangers, high-temperature blowers, and other applications that demand high resistance to corrosion and thermal shock.

Another limiting factor is the final machining often required to produce the finished part. Conventional grinding wheels, for example, are no match for the extraordinary hardness of silicon carbide and silicon nitride. One alternative is the diamond grinding wheel developed jointly by Toshiba and Osaka Kongo Seito, an industrial abrasives company. The wheel not only far outlasts other types of grinders, says Toshiba's Sugie, but is designed for achieving the extremely close tolerances often required in electronic and medical ceramic parts.

But if Japan is to lead the world into the New Stone Age, it must first convince a skeptical audience. "Many customers are very interested in these ceramics," says Shougo Shimizu, chief specialist of Toshiba's materials group. "But they often need a lot of selling before they take the chance." That reluctance was one of the reasons Toshiba teamed up with Koyo Seiko in its bearings development; the latter's excellent reputation among its customers added credibility to Toshiba's materials and processing technology.

But it is probably the automobile industry, says Shimizu, that holds the key to success for the new ceramics: "If we can overcome some of the problems that still remain, and convince the automakers of the reliability of the components, that will be an enormous vote of confidence for advanced ceramics." □

LOU JONES

Homing in on healthcare

OKAYAMA—Biotechnology, one of the Japanese government's major priorities for the 1990s, is being pursued almost feverishly by some of the nation's leading corporations. Japan's admitted weakness in basic research, moreover, could soon be overcome through international joint ventures and aggressive recruitment and training programs.

Considering Japan's limited natural resources, it's only to be expected that much of the research should focus on chemicals and agriculture—bio-alternatives to petroleum processes, for example, and the creation of new crops by means of plant tissue culture. But potentially huge global markets are also a strong lure. In fact, most Japanese biotech researchers have zeroed in on healthcare—the profitable worldwide market in vitamins, vaccines, antibiotics, and genetically engineered cell products. Much of this research in turn hinges on immunology (the study of the body's natural defense system).

Immunology is the core of a variety of new products being developed at Hayashibara (Okayama), a century-old fermentation and foodstuffs company that is still considered only a minor player in biotechnology. That image is due for revision, however, with the recent opening of its \$12 million Fujisaki Institute, which houses, among other things, more than 50,000 hamsters. Under an unusual cell culture system, designed largely by Hayashibara personnel, the newborn animals serve as "cell factories" for the production of interferon and other products.

The newborn hamsters are injected with a small quantity of human cells or hybrids (specialized cells formed by fusing two different cells), then left to mature normally. Because these animals' immune systems are weak, the rejection rate is very low. The cells multiply for three or four weeks; in the case of interferon manufacture, they are injected with specially grown viruses that act as inducers—that is, they prompt the cells to make and secrete interferon, just as they do in the human body during a viral infection. The cells are then removed from the hamsters and the cellular products extracted and purified.

In a land where spiritualism seems to pervade all facets of life, the destruction of animals in the name of science is not taken lightly. Young female technicians gather once a month to pray in the small garden outside the laboratory. "They hope to appease the spirits of the sacrificed hamsters," says a Hayashibara spokesperson, "and thus spare



Cardiac enzyme research is one example of how Japanese biotech firms are zeroing in on fast-growing healthcare markets.

their own children a possible fate just as tragic."

Many biotech companies in the U.S. and elsewhere have rejected such animal "cell factories" because of the high maintenance costs and complex, time-consuming purification processes. But Hayashibara, working on the theory that anything that can be made by conventional *in vitro* (outside the body) cell culture can be made more efficiently in animals, is convinced that it's on the right track.

The company is now using the hamster system to produce experimental amounts of alpha- and gamma-interferon, as well as two cancer-attacking proteins produced by the immune system: carcino-breaking factor and tumor necrosis factor. Both drugs are now in clinical trials—the former by Hayashibara and the latter by Asahi, a Tokyo-based chemical company. The hamster system could also be used to produce monoclonal antibodies, says Jun Minowada, executive director of Hayashibara's new cell center. For now, though, the company does not intend to jump onto that crowded bandwagon. Likewise, it has no plans to develop recombinant DNA technology. "But that isn't to say that we'll never change our minds if the right opportunity arises," says Minowada.

Immunology is also a primary focus at Suntory (Tokyo), one of Japan's largest and best-known producers of foods and alcoholic beverages. The company launched its pharmaceuticals business six years ago, on its 80th birthday. "We knew that there were a lot of big pharmaceutical companies in the world," says Takanobu Isobe, manager of pharmaceutical planning. "To be a front-runner, we had to find something new and move fast with it."

Move they did. Within three years, company researchers had developed the Suntory Computer-Aided Drug Design System (SCADDS), a proprietary software system with which researchers can evaluate complex drug syntheses on a computer before launching costly laboratory work. And while Isobe says Suntory's drug business is "still a baby," 40% of the 300 workers at the company's Kyoto research center are in the pharmaceutical division.

Specific research areas include cell fusion and recombinant DNA technology, diagnostics and therapies based on monoclonal antibodies, and cell products such as gamma-interferon and tumor necrosis factor. The latter products are being developed through joint ventures with Schering-

by H. Garrett DeYoung



Above: A researcher demonstrates a computerized drug design system recently developed by the food company Suntory to help it enter the pharmaceuticals business. Right: At Hayashibara, eggs are inoculated with a virus that is later injected into special cells to promote the secretion of commercial quantities of interferon.



Plough (Kenilworth, N.J.) and the Swiss firm Biogen. A cardiac drug, meanwhile, is now in the clinical research phase, says Isobe, and will be licensed for manufacture by other companies. The drug, called SUN 1165, is reportedly stronger than its market competitors but less toxic.

Suntory may not be the largest of Japan's new biotechnology companies—that distinction belongs to Mitsubishi Kasei and Wakunaga Seiwaku—but it appears to rank among the most aggressive. In the company's move to quickly carve out a role as a major player, for example, corporate planners actively recruited personnel from the competition—an unofficial but palpable taboo in Japanese industry. "There are more than 150 biotechnology companies in Japan," explains Koh-Zoh Shimura, a pharmaceutical division planner, "so we have to work hard to get the people we want. Moreover, it takes 10 years or more to get a new university graduate up to speed. We needed researchers who could go to work for us immediately."

Immunological research also plays an important role at Fujisawa Pharmaceuticals (Osaka), although the company has at least temporarily removed itself from the crowded monoclonals market. "We decided to put most of our effort into the businesses we know best," says Hiroshi Imanaka, group director of planning and development. Those businesses include vitamins, animal health products, vaccines, and antibiotics—mainstay businesses that last year accounted for some \$798 million in sales (about 85% of the company's total).

But this emphasis on basic business doesn't mean that Fujisawa isn't chasing down new opportunities. Imanaka notes that a large portion of the company's 1984 sales came from products less than seven years old. As with most other Japanese biotechnology companies, many of the most promising products have arisen through joint ventures. Collaboration with Biogen, for example, has resulted in a strong research and marketing posture with genetically engineered human tissue plasminogen activator (hTPA), a protein that may be useful in controlling blood clots in heart patients; and its partnership with Genentech (South San Francisco) gives Fujisawa the Japanese manufacturing rights to that company's tumor necrosis factor.

But despite such cooperation, Japanese firms remain formidable rivals—both for foreign firms and for one another. "The Japanese have an extensive pool of talented labor in a very labor-intensive industry," says Ralph Christoffersen, executive director of biotechnology at Upjohn (Kalamazoo, Mich.). "Combined with the government's commitment, that makes Japan a very tough competitor in biotechnology."

Japan's rapid strides in biotechnology are all the more remarkable when one considers that the country wasn't even in the race until about five years ago. That was when the Ministry of International Trade and Industry (MITI) tagged the field as one of several key technologies for full commercialization during the 1980s. One result of that designation was a whopping 55% increase in the nation's

overall biotechnology research and development budget between 1983 and 1984.

Industry-government relationships constitute one of the fundamental differences between Japan and the U.S. "The Japanese government is much more of a partner to industry than in this country," says Upjohn's Christoffersen. "By setting this national goal, Tokyo provides a direction for industry and support for the universities, and can streamline the new-product approval process."

But the situation in Japan is not without problems. Because so much of the new biotechnology hinges on products never before manufactured and processes never before employed, the country now faces many of the same uncertainties that beleaguer executives throughout the world—mating technical expertise with marketing know-how, for example, and forecasting sales of a drug for which there has never been a demand.

Despite some Americans' high opinion of Japan's labor pool, many Japanese executives lament the scarcity of "good people." To help ensure a steady supply of trained

personnel, Hayashibara has instituted a new policy: "We select bright youngsters and send them through the university," says corporate director Sumio Kamiya. "With so many students becoming interested in biotechnology, you have to offer these benefits to be competitive."

Although foreign observers often laud the government's involvement, many Japanese researchers are less than enamored of this relationship. "We don't think our government is especially supportive of industry," says Fujisawa's Imanaka. "We receive no funds, for example. And even though the technology is being encouraged in various ways, it can still take up to 10 years to bring a new drug from the idea stage through the govern-

Fujisawa's Imanaka is concerned about Japan's ability to step up its pace in basic research.



ment approval process." Other sources note that while MITI actively promotes the formation of industrial associations and councils—the Biotechnology Development Research Association, for example—such organizations are not always relevant to the business direction of a given company. "All it means to us is more paperwork," complains one executive.

But perhaps the thorniest problem of all is the nation's spotty record for developing products from the ground up—a shortcoming that many researchers openly worry about. "We're much more skilled in applied science than in basic research," says Imanaka. In an effort to change that condition, Fujisawa recently opened a laboratory in Osaka and staffed it with some 125 researchers. Other large companies, likewise acknowledging the vital importance of basic research to commercial biotechnology, have also recently established or expanded major basic research facilities. "If we fail in this," says Suntory's Shimura, "I just don't think we can survive as a serious force in biotechnology." □

A new look at

Summary:

GTE lighting research operates on many fronts: a space lighting lab to study the motion of gases in a gravity-free environment; the use of various isotopes to enhance the output of fluorescent lamps; the production of light directly from excited molecules.

The science of lights and lighting might seem to be rather mature. Indeed, the standard light bulb has changed very little in at least half a century.

But lighting science is on the brink of revolution. Recent work by GTE points the way to major improvements in every type of lighting.

Lighting research in space.

One of the most powerful and efficient light sources is the high-intensity-discharge (HID) lamp. Its light is derived from gases and ionized vapors which are excited in an electrical arc contained in a quartz arc tube.

The gases circulate by gravity-induced convection, which mixes the radiating species in the arc. This tends to obscure other vital processes such as diffusion, cataphoresis (motion of ions toward the negative electrode),

magnetostriction and vapor condensation. Researchers have wanted to observe these processes at leisure, in the absence of convection, for many years.

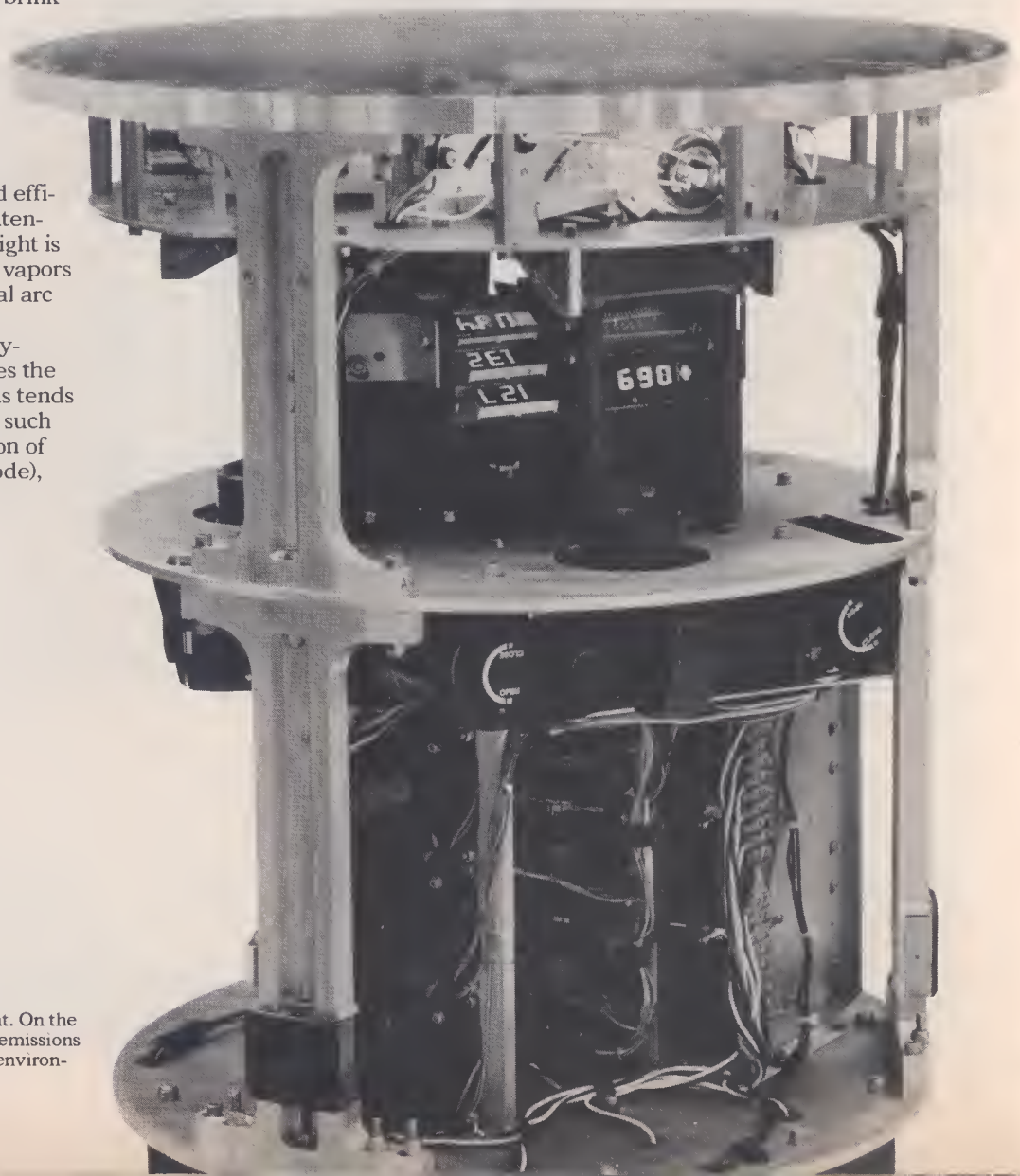
GTE has achieved this goal in a first-of-a-kind experiment aboard the space shuttle. A payload of three metal-halide HID lamps was operated in the microgravity environment of the orbiter. Each lamp was lit for half-hour periods while detailed spectroscopic, light output and electrical measurements were taken.

The results have substantially strengthened the technological underpinning drawn upon for lamp design. GTE scientists now have critical information and new insights that will produce lamps with brighter, whiter light.

Untrapping excited atoms.

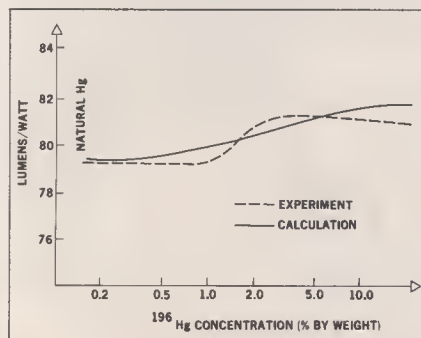
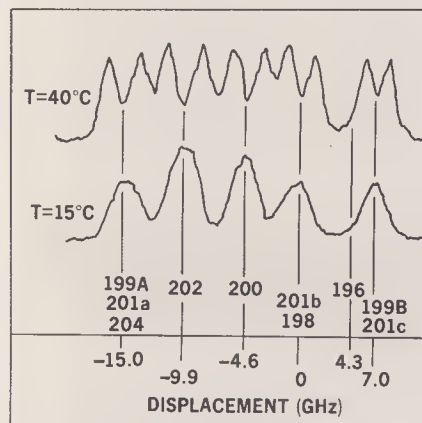
Improvements in fluorescent lamps are on the way, too. As just one example, GTE has discovered how to increase the efficiency of these lamps by about 5%.

Mercury vapor in the lamp emits



Payload for the GTE space experiment. On the top layer are three HID lamps, whose emissions were investigated in the microgravity environment of the space shuttle.

an old science.



ultraviolet light when it is excited by the electric current. This light is transformed into white when it strikes the phosphors coating the glass tube but some ultraviolet is reabsorbed by the mercury vapor, limiting the lamp's efficiency. GTE researchers have found, however, that by increasing the level of ^{196}Hg isotope from its naturally-occurring 0.15% to 3.0%, more ultraviolet light escapes to the phosphor. Output improves about 5%.

Light from molecules?

In the future, light may be produced directly from excited molecules in low-pressure lamps. The light spectrum is in broad bands, rather than the narrow-line emission from mercury or sodium atoms.

GTE researchers are investigating ways to produce white light from molecules as the basis for a totally new lamp.

The chemical make-up of the molecules and their behavior in the excited state are undergoing critical studies. In many cases, GTE is applying electrodeless technology with RF power sources as exciters.

This new way of looking at light bulbs promises high-efficiency, long-lived, cool-running light sources with many industrial and residential applications.

The wonderful world of light.

At GTE, we are working on many projects aimed at bringing about the revolution in light. New electrode materials, improved sealants, excimers—these and more are on the GTE research agenda.

The box lists some current papers pertinent to GTE lighting research. For any or all of these, you are invited to write GTE Marketing Services Center, Department TP-L, 70 Empire Drive, West Seneca, NY 14224. Or call 1-800-828-7280 (in N.Y. State 1-800-462-1075).

Pertinent Papers

Convection and Additive Segregation in Metal-Halide Lamp Arcs: Results from a Space Shuttle Experiment
Symposium on Science and Technology of High Temperature Light Sources, Electrochemical Society Meeting, Toronto, 1985

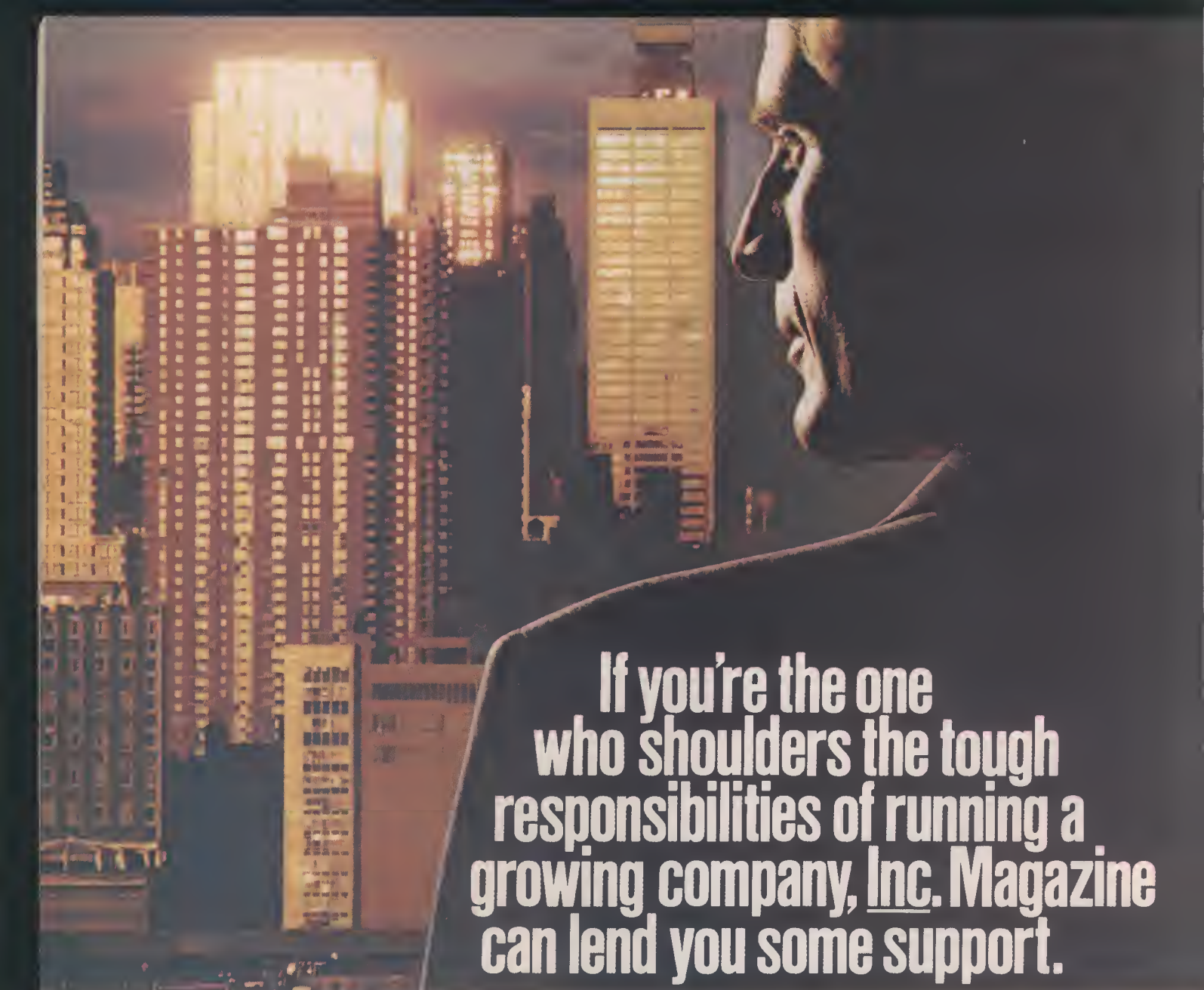
Arc Discharge Convection Studies: A Space Shuttle Experiment
Proceedings of a symposium held at NASA Goddard Space Flight Center, Greenbelt, Maryland, August 1-2, 1984

Energy Conservation Through More Efficient Lighting
Science, Volume 226, pp. 435-436, October 26, 1984

Enhanced HgBr emission at low pressures
Applied Physics Letter 42, May 1, 1983

Bound-free emission in HgBr
Applied Physics Letter 41, November 1, 1982

GTE



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Inc.
PROFITABLE EXPERIENCE

Getting great reception in TV and audio

TOKYO—In thirty years, Japanese consumer electronics products have moved from the bargain bins to center stage. In the process, the major Japanese vendors of these products have devastated manufacturers in North America and Europe. They are so successful, in fact, that they now build branch plants in the West, exporting not only their manufacturing technology but also their managerial style.

Not everything has gone smoothly for the Japanese; some consumer technologies, such as hi-fi equipment, are close to becoming sunset industries in a saturated market, and products that have been successful domestically—such as “sing-along” stereo systems—have failed in foreign markets. Moreover, the competition from Hong Kong, Taiwan, Singapore, and South Korea has put great pressure on the Japanese to produce even more efficiently. In many cases, the Japanese have decided to join them. For example, a product may be designed and pilot production begun in Japan; then, when all the bugs are worked out, the entire assembly line is shipped off to another Asian country for the mass production run.

The Japanese have earned their status with quality goods at attractive prices. In domestic and world markets—whether for TV sets, videocassette recorders, or audio equipment—Japanese firms compete against each other fiercely, and the consumer has come out the winner.

by Cary Lu

In television the Japanese have failed to displace the mainline American companies such as RCA and Zenith. Yet they dominate the American market for small-screen color sets and have captured a large share of the other sizes.

The television market has shifted in the past decade as color televisions reached virtually all households. Overproduction has made standard TV sets commodity items, and because of intense price competition, they return little profit. Therefore manufacturers are now looking toward new technology to build the more profitable premium models.

Surprisingly, the Japanese were caught behind on the latest improvement in television: digital signal processing circuits. They must buy digital chips from ITT Intermetall in Europe; their own chips are still a year away. Nevertheless, Toshiba's sets with digital circuitry were the first to reach the American market, and the race is on to add features. These first digital TVs offer little useful improvement over older designs (how often do you really want to watch a second picture inset in a larger picture?). Yet digital technology will bring important advantages in the coming years. New sets will incorporate sufficient random-access memory to store an entire frame so special-purpose computers can process the image. Several companies have already demonstrated prototypes with advanced features; Toshiba has a ghost-canceling circuit, and Sony has scan

Reiji Hattori, president of Seiko, shows off the first commercial flat screen color television.



ETHAN HOFFMAN

doubling—all 484 viewable lines (of the nominal 525) will be displayed at a time by showing both fields in a frame, making the image appear sharper. Such features will prove invaluable both for projection televisions and for the jumbo CRTs such as Sony's 30-inch and Mitsubishi's 35-inch tubes.

Some television innovations face less certain prospects. The Japanese have developed several TV designs specifically for videotex, both for their domestic market and under contract to American or European promoters. But the videotex goal of providing video information over a telephone line remains a technology in search of a purpose even in gadget-happy Japan; so far, services around the world have flopped.

The newest video product is the video still camera. Shaped like overgrown 35mm single-lens reflex film cameras, these devices from Sony, Canon, and a dozen other major names use a solid-state image sensor called a charge-coupled device (CCD) and record analog video frames on a tiny 1.85-inch floppy disk. The Japanese electronics industry has already standardized the disk format (24 full frames or 48 fields per disk), although the products have not yet reached the market. You'll be able to view the images either on a TV screen with a disk reader or on paper with a video printer. The printers under development mostly use either inkjet or thermal transfer technology; Mitsubishi is already selling such printers, and Toshiba has developed a compact color printer using thermal transfer. Black-and-white video printers will sell for a few hundred dollars, the simpler color units near \$1000.

The videocassette recorder has already zapped Super-8 home movies, and video proponents hope that the new cameras will ultimately do the same for still photography. The video still camera has a long way to go, however. Toshiyuki Yamada, general manager for systems LSI in Sony's Atsugi semiconductor group, points out that as of 1984 the firm's best CCDs had a resolution of 500×582 pixels. The smallest fabrication dimension in such a CCD is 1.4 microns, about the same circuit density as a 256-kilobit dynamic RAM chip. But the CCD must handle a 50-decibel dynamic range, not just the 1s and 0s of a digital chip. "You can't depend on redundancy," says Yamada, "because if there is one flaw in the picture you can see it. Sony is the only firm in mass production of CCDs, with 30% yield, which is amazingly high considering the rigorous requirements for these chips." To equal 35mm film, though, they need still more resolution: 1000×1000 pixels, or even 1500×2000 .

In the long run, flat screens will replace the present bulky cathode-ray tubes in our TV sets, but flat screen progress has been slow despite major research and development work. The new liquid crystal display television sets from Seiko, Epson, Casio, and others remain a novelty, more impressive for the fact that they work at all than for their actual performance. Although their prospects improve as the screen size (currently under three inches) grows, the manufacturing difficulties grow as well. The power-hungry CRT should dominate for the rest of the decade, secure because of its low cost and high picture quality. And the CRT still has some tricks left; Sony's sideways CRTs (used in the Watchman sets) are about to be joined by color versions, and Matsushita (Panasonic) has shown prototypes of an ingenious flat CRT array with a matrix of miniature electron guns and deflection assemblies.

Advances in television image sharpness are not always a good thing. Many program sources, including virtually all cable systems, are marred by noise and color distortion. As

a result, high-quality television sets often include sharpness controls to degrade the image (much as a treble filter removes phonograph record noise). Increasingly the major source of poor images is the videocassette recorder.

VCRs have been the most profitable new consumer technology of the past decade. Sony's Beta format was the first to succeed, yet it has not fared well against Japan Victor's VHS (Video Home System) format. These two half-inch formats have competed for a decade by adding new features. The early competition lengthened the recording time by slowing the tape speed down to a crawl. A second phase added stereo sound, first in conventional linear tracks along the tape edge, and then in high-quality frequency-modulated form in the video track area.

Despite tremendous success, the Japanese VCR makers face major challenges. VCRs have been so popular that sales of half-inch units are approaching saturation; over half of all Japanese households already have one. In the more slowly developing U.S. market, the peak is still probably 18 months to two years off. And the Japanese must now compete with the South Koreans and the Taiwanese, who will likely push VCR prices below \$200 this year with products that are competitive in performance.

From a consumer's standpoint, the biggest problem with VCRs is the picture. No consumer VCR comes close to the quality of a clean broadcast signal. Sony has helped a little with SuperBeta, a modification of the Beta format standards that increases the video bandwidth by raising the video carrier frequency. SuperBeta (as well as the possible VHS response) offers only a modest improvement and is in some ways incompatible with older VCRs.

The problem is that the decade-old Beta and VHS standards need a major overhaul. The necessary steps, however—such as using a much higher carrier frequency with evaporated-metal tapes—would render existing VCRs obsolete. Excellent picture quality is possible in a half-inch cassette. Indeed, the Japanese already sell such systems in the high-quality Betacam and VHS M-format recorders produced for the broadcasting industry. But these formats use completely different recording techniques. To achieve their true broadcast quality, the formats whip through "two-hour" tapes in 20 minutes. Nevertheless, because it can record one hour on a "two-hour" tape, the new VHS M-2 professional format from Matsushita might attract the videophile—at least the well-heeled videophile; these recorders cost over \$10,000.

For the consumer market, the major new developments have shifted away from half-inch to 8mm video, a new standardized format that will ultimately replace Beta and VHS. Despite the tiny cassette size (about the same as an audio cassette), 8mm will ultimately boast more features than the present half-inch formats. Sony's 8mm recorder has a flying erase head, mounted in the head drum with the record/playback heads, so it can perform edits better than the fixed erase heads in any standard VHS or Beta VCR. Unlike a fixed head, which must erase many frames at a time, a flying head can erase an individual frame or field. On the early 8mm recorders, the sound was mono only (via both an edge track and an FM track in the main video track), but the latest units boast digital stereo sound and even provide for an extra-long-play audio-only format—six hours of digital sound on a one-hour tape. These sound tracks can be put to other purposes, such as cues for editing.

Compared with half-inch, the 8mm format offers decisive advantages in size and weight, and the picture quality



Tokyo's Akihabara district (above) is the world's largest electronics bazaar, selling everything from memory chips to refrigerators.

Eight-millimeter video will ultimately replace the present half-inch Beta and VHS formats. Toshiba makes Polaroid's camcorder (far left); Sony is selling one under its own name (near left).

already matches Beta and VHS. The manufacturing precision is about double: half the magnetic particle size in the tape and half the head gap width, greatly increasing the recording density over the earlier formats. Although present 8mm cassettes are limited to 90 minutes recording time, two-hour tapes are appearing, and half-speed recorders will raise the time limit to four hours.

The first 8mm entrants in the U.S. market were Kodak and Polaroid, selling Japanese-made units. The first Japa-

nese company to sell 8mm video under its own name will be Sony, motivated in part by its declining fortunes in the Beta format.

Another lucrative but trouble-prone area is audio equipment. The Japanese swept up the hi-fi market in the 1960s and 1970s, ousting all the mainline American makers except in loudspeakers. But the victory has turned hollow. The audio

market has leveled off and may never grow significantly again. Hi-fi is a mature technology; there simply isn't much left to do. By the early 1970s, the core electronics—tuners and amplifiers—reached functional perfection as distortion figures dropped below 1%, so further innovation can yield little audible improvement.

As a result, the Japanese audio manufacturers dress up hi-fi equipment with every automated gizmo they can think of. The front panels now light up like a Las Vegas casino. And many controls have actually become more difficult to use; slider and push button volume controls, for example, are much clumsier than the old-fashioned knob.

The only significant improvements in hi-fi since stereo arrived in the late 1950s have been the introduction of two new program sources: cassette tape decks and compact disc (CD) players. Cassette decks have reached a plateau of acceptable sound for ordinary needs. CD players supply the best medium for music distribution today. But the digital nature of CD players destroys the traditional idea of building a product line with a series of increasingly expensive and profitable models. The CD format is fixed; there are none of the tricks that fancy record players have used to coax a slightly better sound out of a stylus riding in a groove. A \$250 CD player sounds pretty much like a \$1000 unit (the differences seem trivial compared with the variations among identically priced speakers). And the overall market may not be huge. Although CD players are selling well as prices drop below \$200, the potential market is restricted to those who already have a hi-fi system—only about a third of U.S. homes (about two-thirds of Japanese).

The CD will find new uses. New players from all the major manufacturers will generate still-frame video—up to 1500 limited color graphics, or text to accompany the sound. Modified forms of the CD itself may also appear; in one proposal, a lower-quality but still effective encoding format will stretch out the playback time to 32 hours, enough to store all the Shakespeare plays on a couple of discs.

The last missing piece of audio gear is a digital recording format. Although digital sound adapters for VCRs have been around for a few years, their sales have been limited; newer, more convenient formats are likely. There will probably be two formats, one using fixed recording and playback heads, and a second using rotary heads like a video recorder's. The rotary head version will probably be 8mm video with additional electronics. Digital sound recording is impressive, but not sufficiently so to inspire wholesale replacement of the ubiquitous standard cassette recorder. Nevertheless, digital recorders will appear in high-end hi-fi systems within two years. Consumer optical disc recorders are somewhat farther off, although both Nakamichi and Matsushita already sell industrial versions (Matsushita's is specifically for storing analog video images). Both of these units can record only once and cannot erase.

In audio equipment, the Japanese compulsion to miniaturize is nearing its practical limits. The latest Walkman-type cassette units are barely larger than the tapes they play, and radios are now the size of credit cards. Further size reduction can't help; our fingers won't get smaller, so the size of the controls becomes the absolute barrier. As a result, the circuitry will move inside the controls. Some room for improvement remains. Both cassette players and portable CD players can use better mechanical stability and shock resistance, and battery life continues to be a problem. In the meantime, manufacturers are resorting to novelty items: Sony even has a double cassette Walkman with two independent tape transports.

The recession of 1981–82 shocked the major Japanese audio companies, some of whom lost money for the first time ever. The recession sparked murderous price cutting to dispose of bloated inventories, and prices have stayed low. The vertically integrated manufacturers, such as Matsushita (Panasonic/Technics) and Hitachi now have a significant advantage over the assemblers such as Teac and Pioneer. Teac diversified into computer components, and Pioneer went into video. Neither has been very successful.

Sometimes Japanese manufacturers develop a new line of products but can't get anyone to buy them. During an earlier recession in the mid-1970s, several Japanese companies latched onto the short-wave radio market as a way to use up their excess manufacturing capacity. To drive the market, the companies sponsored listening clubs in Japan. A brief flurry of interest was soon drowned out by the inherent noise of short-wave reception, and even the usually disciplined Japanese consumer soon lost interest. Now only Sony and to a lesser degree Matsushita and Trio-Kenwood keep an active interest; a few other manufacturers maintain half-hearted development efforts.

What will be the next great success? The incorporation of microprocessors has added features, and occasionally real value, to an array of products from knitting machines to food mixers. Some technologies, such as videodiscs, show great promise but have not done well. And the home computer market remains uncertain.

The most successful Japanese home computers have not been introduced in the United States; their software is not really competitive except for games. The MSX home computer, built by most major Japanese electronics companies, is going through a period of development and may emerge as a controller for all the other consumer technologies. That way, videocassette recorders, microwave ovens, and home security systems could all be tied together. Of course, many others have proposed using home computers for controllers, but only the Japanese companies make the entire range of appliances—including the computer—that would plug into the system. The advantages aren't compelling, although you will be able to program all the products remotely by telephone.

The awesome Japanese record in consumer electronics raises important questions about the future of Western companies. Until recently, most of the great product concepts came out of the West: RCA developed color television, for example, and Philips in the Netherlands developed the audio cassette and the optical disc. But today the front-runners are the Japanese. They have taken the lead not only in selling established consumer goods such as color TV sets and cassette decks but also in marketing new ideas. It was the Japanese, after all, who brought the compact disc to fruition. And it was they who produced the winning VCR formats.

By contrast, in the past decade RCA tried just one major new technology, the CED videodisc, and it failed. Philips's videocassette format likewise fizzled. Instead of taking out licenses to manufacture VHS or Beta VCRs, both RCA and Philips have been reduced to marketing Japanese models. The half-dozen Japanese companies that failed with their own videocassette formats went on to retool and make recorders for the successful formats.

For U.S. and European companies, peering into the future is a chilling prospect: The competition for the new consumer technologies is not between Japan and the West; it is strictly among the Japanese. □

Playing to win a new generation

T**SUKUBA**—Anyone who doesn't take seriously Japan's stated national goal of becoming the global leader in computers can't be paying attention. Already the world's number two computer maker, Japan is making strong moves to expand its share of today's markets while developing superspeed computers and Fifth Generation (artificial intelligence) systems for the '90s and beyond.

As the next generation of processors takes shape, Japanese computer companies are introducing a wide variety of highly competitive commercial computers. Shortly after IBM announced its new 3090, or Sierra, series, both NEC and Hitachi promised superior systems. For the top uni-processor in its planned Acos 1500 line, NEC claims 41 million instructions per second (MIPS)—about a third faster than IBM claimed for its top model. Hitachi says its M682H four-processor configuration will match the performance of IBM's 3090/400 four-processor equivalent, but will take half the floor space, be available a year earlier, and cost 5% less.

Although Japanese computer makers have concentrated on selling their mainframes domestically, they are gradually expanding overseas markets through alliances with U.S. and European computer vendors. In the U.S., Fujitsu sells through Amdahl, Hitachi provides IBM-compatible machines to National Semiconductor, and NEC builds computers for Honeywell. Even when the Japanese do not build the computers, overseas advances frequently depend on their circuit technology. In England, for example, ICL has just announced a powerful new system using its 50-mega-bit-per-second optical local-area network called Macrolan. In a dual-processor configuration, it runs at about 20 MIPS, somewhat slower than IBM's new 3090/200, but it takes only about a quarter of the space and power required for the IBM system. ICL developed its own computer architecture, but used fast ECL (emitter-coupled logic) circuits made from Fujitsu's 8000-gate arrays.

Even with this steady progress, Japan's push toward world leadership in computers may not come from today's commercial machines. Through two high-priority national



Koji Kobayashi is chairman and CEO of NEC, which has announced computers reportedly faster than IBM's Sierra series.

programs, the Japanese hope to leapfrog today's technology and create a whole new generation of computer systems. MITI's Super-Speed Computer Project is an eight-year (1982-89) \$100 million program. An even more ambitious effort is the decade-long Fifth Generation Computer Project, aimed at pioneering new technologies for tomorrow's artificial intelligence systems. Government funding initially set at about \$450 million will be matched by company contributions. Successful results later in the decade could boost spending toward \$1 billion.

There is a vital distinction between the Super-Speed Computer and the Fifth Generation projects, stresses Hiroshi Kashiwagi, head of the computer systems division at the national Electro Technical Laboratories (ETL) in Tsukuba. "The first is for high-speed numerical computation," he points out, "while the second is for symbolic processing."

The Tsukuba labs provide some support for both programs. The high-speed computer project's goal is a system that will work at 10 billion floating-point operations per second (10 gigaflops). Private companies are also collaborating in this national effort, and already they are pushing the state of the art in supercomputers. NEC has built a parallel vector processor, the SX-2, that achieves 1.3 gigaflops, claimed to be the world's fastest supercomputer, and Fujitsu and Hitachi are not far behind. This potentially high-growth market is especially attractive because IBM has stayed out of it; much smaller U.S. competitors Cray Research and Control Data have been world leaders.

The superspeed project is centering on parallel architectures and software for parallel machines, new kinds of high-speed devices at high levels of integration, and the construction and evaluation of a prototype machine with an extremely fast computing engine. Three types of devices are being developed for such systems: superconducting Josephson junctions (JJs), high electron mobility transistors (HEMTs), and gallium arsenide (GaAs) integrated circuits. Support of the final system, including logic design methods, computer-aided design (CAD) tools, packaging and cooling techniques, and system test methods, will also be developed.

by Robert Haavind

Today's supercomputers commonly use fast ECL circuits on silicon chips with gate delays of perhaps 350 picoseconds. Chips with tens of thousands of devices on them are employed. Memory chips carrying 256K (2^{18} or 262,144) bits of storage offer access times down to about 70 nanoseconds.

Targets for the superspeed project are 10 ps/gate for JJs and HEMTs, and 30 ps/gate for GaAs devices, with integration levels of 3000 gates per chip. Memory targets are access times of 10 nanoseconds with 16K (16,384) bits of storage per chip. This should be sufficient to prove the new technologies, and individual Japanese computer companies involved in the project would be expected to carry the technology forward from that point.

Already, Japan's computer/semiconductor community has done extensive work on the development of and production techniques for gallium arsenide chips. A single-chip Josephson junction processor, with logic and memory on the same chip, should be completed within a year or two, according to Kashiwagi. Work on HEMT devices, both silicon and gallium arsenide, remains experimental.

One approach to parallel architecture is the data-flow computer. A prototype of a processing element for a dataflow machine called Sigma-1 is under construction in ETL's computer architecture laboratory. To speed computation, instructions fan out to available processors in parallel. They are executed, however, only when the requisite "tokens" tagged onto arriving data indicate that all required data have been received. The Sigma-1 will have 256 such parallel processing elements and should be capable of operating at 100 megaflops when completed about the middle of next year, according to Toshitugu Yuba, chief of the section.

Such parallel processing architectures may prove useful both for superspeed computation and for artificial intelligence (AI) systems. But the route to faster computation is much clearer; there is no consensus as yet on how to build knowledge-based machines that can understand natural language and apply reasoning and common sense.

To address this problem, Kazuhiko Fuchi has assembled a team of young researchers into the Fifth Generation development group at the Institute for New Generation Computer Technology (ICOT) in Tokyo. Although it is unprecedented in Japan to assign such a vital mission to young engineers and scientists, who traditionally must put in a lengthy apprenticeship before moving into critical posts, Fuchi was allowed to draw the brightest young talent from ETL and eight Japanese computer companies because of the long-range nature of this unusual project.

M. Kusama, an ICOT researcher in the organization's Tokyo offices, stresses that "the Fifth Generation Project is not working on artificial intelligence. We are developing hardware and software tools." Actual artificial intelligence applications will be developed by individual companies as new systems—the tools—become available. ICOT will build an engineering model of a knowledge-based processor over the 1985–89 period, to be followed by construction of a prototype system in 1990–93. Meanwhile, studies of how the brain processes information are being done for ICOT at ETL in Tsukuba.

Machines that can reason will probably require a variety of parallel architectures, according to Hajime Karatsu, a technical adviser to Matsushita Electric in Osaka. Karatsu heads one of several committees set up to advise ICOT. "At one time," he says, "it was believed that a single parallel architecture could be chosen for Fifth Generation systems.

Instead, it appears that four or five competing parallel approaches will be investigated simultaneously." This too is unusual for such a program in Japan; narrowing choices early on has traditionally been a way to make fast progress with a limited pool of talented researchers. The need to pursue several routes to parallelism reflects the difficulties of forcing early choices in such a pioneering effort.

In fact, one such choice in the program has stirred considerable controversy: The Japanese decided to base their work on Prolog, a language widely used in Europe. But the U.S. artificial intelligence community, which works much more with LISP (a language that grew out of time-sharing system development at MIT), tends to view Prolog as less flexible than LISP. LISP is a symbol-processing language providing great freedom in defining functions and program structure, while Prolog is a more formal language based on logic programming.

Some reasons for Japan's choice are cited by Fumio Mizoguchi, a professor in the department of industrial administration at Tokyo University. Prolog's logic programming structure should make it more amenable to higher-level processing in which hypotheses can be formed, inferences made, and the consistency of knowledge automatically checked. Prolog programs are easier to interpret, says Mizoguchi, because of the more formal structure of the language. LISP's greater freedom makes its programs harder to understand, he feels, and creates the potential for conflicting rules that cannot easily be detected.

Logic programming has another asset, says ICOT's Kusama. Much of the knowledge accumulated by a system is expressed in a form called predicate logic, which closely matches the structure of relational descriptions. Thus it becomes much easier to make linkages from a database in a system with a Prolog-type architecture.

Although Prolog was chosen as a starting point, an evolutionary set of kernel languages has been planned for interfacing between hardware and software in experimental prototype machines. A sequential inference machine was developed early in the program, along with a machine language designated KLO and a user language called ESP (Extended Self-contained Prolog). For parallel operations a more advanced machine language, KL1, was developed, along with a new user language called Mandala.

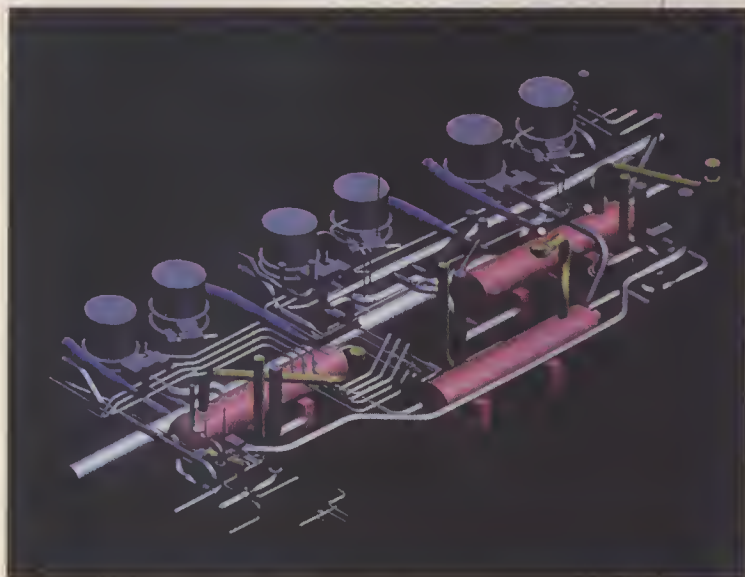
The next objective was to develop hardware and software to enable individual users to interface with a very large knowledge base. Two machines were developed for this stage: a personal sequential inference (PSI) machine and a relational database management machine (Delta), linked by a local-area network (INI, for Internal Network in ICOT).

The results of these projects will be consolidated in KL2, the language being developed for the prototype Fifth Generation Computer. Such a computer will have to converse with a user in natural language, so work in this area is proceeding at ETL, ICOT, and some of the participating companies. Fujitsu, for example, has developed machine translation software that translates 25,000 words a minute from English into Japanese, according to Matsushita's Karatsu.

Even though Prolog is the language chosen for the Fifth Generation Project, Japanese researchers are not ignoring the potential of LISP for artificial intelligence applications. A parallel LISP machine, called EM-3, is being built at ETL's computer architecture lab to serve as a test-bed for parallel control operations. Four processing elements are connected by a routing network in this machine, which makes use



ETHAN HOFFMAN



of eight Motorola 68000 microprocessors.

The Japanese say they would like to see the Fifth Generation effort become international in scope. For example, open meetings are held each year to discuss ICOT's efforts, and visiting scholars from Europe and the United States are invited to work at ICOT for a month at a time. In addition, the U.S. and some European nations have insti-



Kazuhiko Fuchi (top) heads Japan's Fifth Generation computer effort from ICOT's offices in Tokyo. Fujitsu's VP-400 supercomputer (above), which runs at 1.14 gigaflops (billion floating-point operations per second), will bow in December. Hitachi's high-resolution 2000 × 2000-pixel display (left) adds precision to computer-aided design graphics.

tuted collaborative computer projects of their own. But although some observers voice skepticism about how much international sharing of technology will actually take place once these efforts begin to pay off, ICOT's Fuchi argues for worldwide cooperation. "Global rather than merely local efforts are needed," he says, "since the new computer age will benefit all mankind." □

Succeeding at the edges

TOKYO—In an effort to duplicate their successes in consumer electronics, Japanese companies have made repeated attempts to sell complete microcomputer systems in the United States. Thus far, they've failed; their corporate machinery is too slow for such a rapidly changing technology. So the Japanese have instead gone into the components and peripherals markets. Components are less glamorous and less profitable than complete computers, but the manufacturers have had much success; an increasing percentage of the parts in American computers come from Japan. In the peripherals area—printers, plotters, scanners, displays, disk drives—the Japanese are likewise gaining ground.

When it comes to printers, for example, the Japanese own the market, having scored early on. Epson leads in the U.S., and Okidata, Tokyo Electric, NEC, and others all have important shares. The Japanese invasion quickly led to a rout of the small U.S. companies that were the major printer suppliers only five years ago. The first big winners were impact dot-matrix designs, but Japan's Midas touch has now spread to the low-cost daisywheel models. Of the American companies, only IBM seems able to mount a counterattack; it has dropped its distribution of Epson models in favor of its new Proprinter (which nevertheless uses an Epson print head).

In 1986 the glamour printers will be nonimpact designs: laser, LED, LCD, inkjet, and thermal transfer. Laser printers have attracted the most attention recently, spurred by the Canon LBP-CX printing engine. It is the heart of many printers, including Hewlett-Packard's LaserJet and Apple's LaserWriter. The Canon engine has had the low-price field to itself—it sells to OEMs for less than \$1000 in quantity (the required controlling electronics adds considerably to the price). Now the LBP-CX has been joined by competing designs, particularly from Ricoh, Konishiroku, and Minolta. All are major photocopier makers and are using copier components to lower their manufacturing costs. The Japanese are working on the high end of the market as well: Toshiba has described a color laser printer with three imaging and toning assemblies all working on a single photoconductor drum.

This year laser printers will be joined by LED array printers and possibly LCD shutter printers. All three page-printer technologies use a xerographic process to transfer image to paper, but they differ in the way they form the

image on the photoconductor drum. From the user's standpoint, all three are functionally equivalent.

LED printers use a line of light-emitting diodes to form the image. Both NEC and Okidata have LED printers ready. NEC's will be on sale later this year and is much more compact than the laser printers to date; Oki is targeting the OEM market. The LCD shutter printers use a line of liquid crystal displays to switch tiny points of light on and off. Epson and Sumitomo have demonstrated such printers—although competitors such as NEC say that the manufacturing costs of the LCD machines are too high.

Inkjet printers squirt tiny droplets of ink onto paper. They started out as replacements for daisywheel printers but failed. They have since moved into low-cost, modest-quality color printing. The cheap inkjet printers all use a print head mounted on a carriage and create images by scanning across the paper with 6 to 24 nozzles. The carriage motion takes a lot of time, and a new class of inkjet printers will appear over the next two years with a large stationary array of two to three thousand nozzles firing away at continuously moving paper. Stacked arrays will print in color. Several companies are developing such printers, but none has announced specific plans.

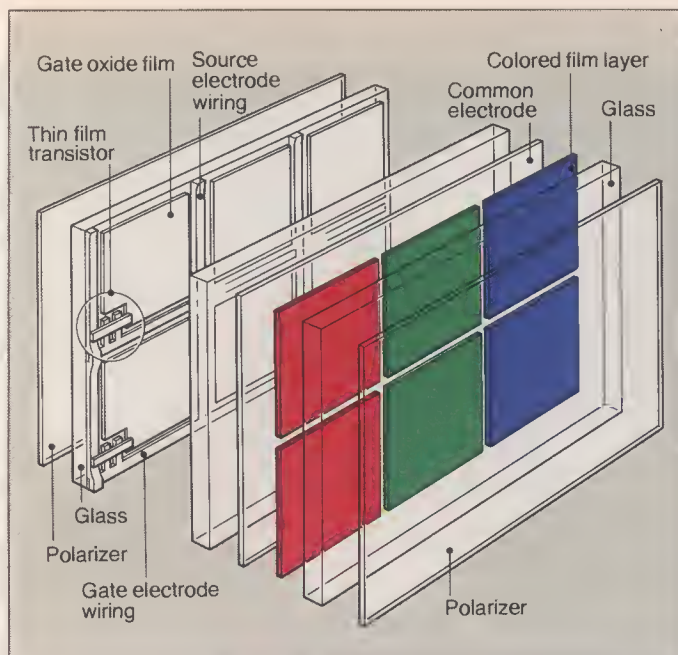
Thermal transfer printers, not to be confused with the low-quality thermal printers that require coated paper, melt tiny dots of resin onto plain paper. Although available for several years in the form of specialized graphics devices, thermal transfer printers are starting to appear for general applications. A likely low-cost configuration (about \$250) will use a nine-dot scanning print head. More expensive versions can work effectively in color through changes of ribbon, but the results thus far have a distracting glazed appearance, and ribbon costs are relatively high.

As for plotters, many Japanese companies, led by Sharp and NEC, are introducing low-cost color models this year—possibly the end of the line for this venerable technology that uses servomotors to push pens over paper. The only remaining advantage to plotters is the ability to change color by changing pens. New printers will duplicate the performance of all plotters except the very largest, which write on paper the size of bed sheets.

Scanners are the inverse of printers; they take existing images on paper and convert them into a computer file, either as graphics or as text with character recognition. The most common scanning technique uses a line of CCD (charge-coupled device) sensors that scan a sheet of paper lengthwise. The lowest-priced scanners are about \$2000 now but will drop below \$1000 soon after they go into volume production. Ricoh has emerged as an early leader in the market, supplying such companies as Datacopy with OEM products. A new class of low-cost scanners will emerge, built into printers, and all manufacturers of low-cost printers will eventually add this feature. A small vertical array of sensors will ride on the print head, adding a scanning function for less than \$50.

For displays, the goal is clear: a flat panel device that can achieve the image size and resolution of a CRT at a competi-

by Cary Lu



Light passing through Epson's color LCD is switched on and off by thin film transistors that control polarization.

tive price. There are five possible technologies: liquid crystal displays, electroluminescent panels, plasma panels, light-emitting diode arrays, and cold cathode arrays. Epson's Susumu Aizawa observes that for all practical purposes the flat panels break down into the LCD and all the rest. LCD is the most promising because it will probably remain the thinnest and consume the least power, and it can display color images. The other technologies—which all emit light—use much more power and have difficulty coping with color. In LCDs, Epson, Sharp, Okidata, and Toshiba produce a full range of sizes with little visible difference. Everyone is trying to improve the screen contrast to get a more legible LCD, but no one seems ready to promise a breakthrough yet.

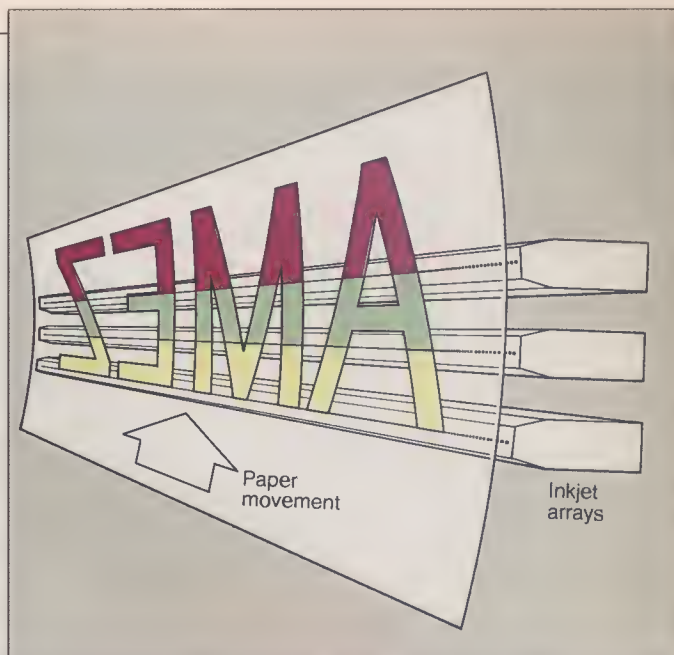
Sharp is also developing the electroluminescent display, a beautiful light-emitting panel that unfortunately consumes both money and power. Sharp's EL displays are used by Grid and other computer makers. The other alternative technologies are receiving less development attention, because they are not considered major contenders.

Of course, every major Japanese company also produces CRTs. Despite all the interest in flat panels, everyone expects CRTs to dominate for the rest of this decade. The pace of development is slowing down as the technology matures, but the tubes will continue to get larger, thinner, higher in resolution, and faster. For high-quality color images, CRTs remain the only practical display.

An arena in which Japan has been particularly aggressive is disk drives. The Japanese are rapidly taking over large segments of this market with price competition that has sunk not only American companies but some Japanese ones as well. Overproduction has caused a glut of 5.25-inch floppy drives; already Sanyo has quit making them.

The next major area is 3.5-inch microfloppy drives, particularly if IBM adopts them for the American market. Sony initiated 3.5-inch drives, but now over a dozen companies make them. The competing 3-inch floppy sponsored by Hitachi has essentially failed.

Continuing reduction in the size of microfloppy drives has already led to Citizen's jewel-like 1-inch-high drives. Yet for a portable computer, even these are too large. Unfortunately, the thinner drives flex mechanically,



Advanced color inkjet printer uses three print head assemblies containing 2000-3000 inkjets each.

throwing the head out of alignment. This problem is especially troublesome for 3.5-inch drives, because they are manufactured with tolerances two to ten times smaller than those of the older 5.25-inch floppy drives. Several companies are working on high-density versions; 5-megabyte microflopies using vertical recording or other technologies are likely in coming years. American manufacturers have virtually given up on making microfloppy drives.

Japanese companies have only recently begun large-volume production of hard disk drives. Although everyone wants the greatest possible capacity, and some designs already exceed 200 megabytes, the most economical configurations for the near term may be 60-MB (5.25-inch, half high) and 20-MB (3.5-inch) drives.

Japanese companies are pursuing technology that can apply to two or more markets. Such double use pushes development and lowers prices by increasing the production volume. This strategy is especially needed in peripherals development, since the computer market is not as large as the consumer electronics market. A successful flat panel display must serve both computers and television. Therefore some computer manufacturers are moving into the television market (Epson now makes LCD television sets, for example), and consumer electronics manufacturers are branching out into computers. Similarly, image sensor technology will gain from its use in both scanners and electronic cameras.

Some products traditionally used only by computers could benefit dramatically when they spread to other markets. Japanese companies have already started prototype production of 1-megabit RAM chips and plan to extend them into a 2-megabit form quickly instead of putting all their effort into a 4-megabit chip that will require new technology. A 2-megabit chip could find wide use as a video frame buffer. Since the TV market is vastly larger than the entire computer market, this application should yield major cost savings for computer memories as well. □

Portions of this article are based on "What future for microcomputers from Japan?" by Epson's Susumu Aizawa, ASCII, April 1985.



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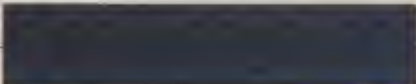
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by using information
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“

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ZAPPING MISSILES IN SPACE

by T. A. Heppenheimer

The concept has a powerful allure: using weapons of precise, discrete destruction to protect against nuclear bombs of indiscriminate destruction. As part of his Strategic Defense Initiative (SDI), better known as Star Wars, President Reagan wants to spend about \$1 billion next year to study lasers and particle beam generators that would intercept and disable nuclear missiles. Working very fast and over long distances, these "directed energy" systems would appear to be exactly what is needed to stymie a nuclear assault.

The biggest payoff would come in zapping a missile during its "boost phase"—its first few hundred seconds after launch—while its rockets are firing. Rocket exhaust emits copious infrared radiation that would be easy to home in on. And with its thin hull stressed from the internal pressure of burning propellant, the missile would be highly vulnerable. Moreover, its destruction would be readily detectable as a sudden loss of speed. A boost-phase kill would eliminate all the missile's nuclear-armed reentry vehicles, while knocking out its decoys. The warheads, presumably still unarmed, would fall back onto enemy territory.

Missiles can be protected from laser beams by coating them with ablative materials like those used in heat shields and nose cones. To kill such a "hardened" missile, a laser would probably have to deliver an energy of about 200 megajoules—equivalent to 80 pounds of TNT—over a square meter of the target. The beam would have to travel about 4000 kilometers (the distance from low earth orbit to the horizon). A spread of one meter at that target distance represents a divergence angle of 0.25 microradian; for comparison, a spread of 1 microradian has been described as equivalent to shooting from Chicago and knocking out a specific window panel in the World Trade Center in New York.

Some lasers emit continuous beams that would destroy by heating, melting, and vaporizing portions of the target. Other lasers produce short bursts of light that would inflict structural shock, similar to that of an explosion. Both continuous-wave and pulsed lasers are being developed for SDI, in part on the grounds that countermeasures against one type would not work against the other.

The other major class of directed energy weapon uses accelerated beams of atomic particles. Particle beams of relatively low intensity could destroy a missile's electronic control and navigation systems. Without computer guidance, the missile would be like a ship without a rudder and could not reach its target. More powerful particle beams might inflict structural damage like a laser.

Several types of lasers are being studied for potential use in a strategic defense system. The leading contenders are x-ray, chemical, and excimer lasers. All have been under development at national labs and military contractors since well before Reagan's March 1983 Star Wars speech; all have been receiving increased attention ever since, and all still present significant problems.

While these lasers differ radically in their construction and performance, they share an underlying physical principle: stimulated emission of radiation, which occurs when certain materials are "pumped" by an external energy source. Typically the electrons in the material's atoms are boosted into higher-energy orbits. The atom returns to its lower energy state by emitting a photon, or particle of light. If this photon strikes another excited atom, a second photon will be released, traveling in the same direction as the first and having the same wavelength. This photon can in turn stimulate other atoms to emit; the chain reaction creates an intense beam of light. Placing mirrors at opposite ends of the laser chamber

selectively amplifies the photons traveling parallel to the material's axis. The resulting beam is extremely well directed.

The x-ray laser is pumped by a small nuclear bomb. Surrounding the bomb are a number of rods, each of which can be pointed at a missile. Detonation of the bomb produces a huge burst of radiation, including about 10^{21} kilowatts of x-rays. The x-rays travel at the speed of light and thus reach the laser rods well ahead of the fireball, which expands at less than one hundredth that speed.

The bomb's x-rays ionize the rods' atoms and cause the material to flash into a superhot gas, or plasma. These ions rid themselves of excess energy by emitting x-rays, which build up into a beam via stimulated emission. The device "lases" for only a few billionths of a second before the plasma dissipates. Thus the bomb's spray of energy is channeled into a brief, directed pulse of radiation.

First demonstrated in 1980 by Lawrence Livermore National Laboratory, the bomb-pumped x-ray laser offers the potential for immense power in a compact system that could be quickly launched into space. The laser has been kept under tight government secrecy. But public reports have recently cast some light onto this shadowy technology. Last October, Livermore researchers stole the show at an annual gathering of physicists by publicly describing a series of over 50 x-ray laser experiments. These experiments served to validate the predictions of a computer program used in the design of x-ray laser weapons.

The x-ray laser that Livermore announced was pumped not with a bomb but with intense pulses of green light; this light came from another laser, called Novette, that the lab had built earlier as part of its research on controlled nuclear fusion. The light pulses were focused onto thin, postage stamp-size films of plastic containing a fine



JOHN TROHA/BLACK STAR

Lasers and particle beams are ideal for strategic defense, say advocates like SDI's Louis Marquet, shown holding a model of a space-based laser.

line of selenium; this metal formed an elongated plasma, which lased in a manner similar to the vaporized rods in the bomb-pumped system. Of the two kilojoules in the green-light pulses, only 0.1 microjoule came back as laser x-rays. That's a conversion efficiency of 5 billionths of a percent—far too low for a practical weapon even if a nuclear bomb were its energy source.

But there has been progress. In an underground test in March, "special optics"—the details of which were not disclosed—focused x-rays from the bomb onto the laser rod, significantly boosting the laser's energy. Similar optics have long been used within hydrogen bombs as a means of focusing x-rays from a fission bomb to touch off the

thermonuclear explosion.

X-ray lasers face another problem, though: how to produce a beam that can go long distances without spreading out. A conventional laser achieves such high collimation (nondivergence) with the two facing end mirrors; but x-rays, which penetrate most materials, cannot be reflected in this way. Thus, while other lasers seek to produce beams that diverge by no more than 1 microradian, the x-ray laser beam will probably spread by at least 50 microradians.

In addition, the x-ray laser suffers from its reliance on a nuclear explosive. Whereas conventional lasers can be tested in a lab, each firing of the bomb-pumped x-ray laser requires a trip to an underground test site in Nevada. More

important, a defense system that requires setting off nuclear bombs in space obviously could be converted to offensive use, a perception not lost on the Soviets. Presidential science adviser George A. Keyworth II said recently that in his view "the bomb-pumped x-ray laser will not be a fundamental part of SDI. We want a defense system that is incapable of initiating war." However, he added that the U.S. should pursue the technology for its potential as a "potent antisatellite weapon" and because "the Soviets may be developing them."

A more likely laser for a space-based defense system is the chemical laser, which draws its energy directly from the combustion of gases. The type pro-

posed for Star Wars uses a two-step reaction: First, molecules of nitrogen fluoride (NF_3) are dissociated to produce fluorine; then this gas flows through a chamber where it burns with hydrogen (or hydrogen's heavy isotope, deuterium). The resulting molecules of HF (or DF) form in a state of high energy; this energy is released as infrared photons with wavelengths in the range of 2-4 microns. The beam forms across the flow of reactants, so the lasing region is kept supplied with fresh molecules. The spent gases exhaust into space, like those of a rocket.

Chemical lasers have been better tested as weapons than the other direct-energy technologies, and they are capable of immense power. In a 1978 test, the Navy used a 400-kilowatt system to shoot down antitank missiles. Since then, the maker of that laser, TRW, has built and tested a 2.2-million-watt DF laser known as MIRACL—Mid-Infrared Advanced Chemical Laser—that is the most powerful laser in the SDI program. The Navy is now testing it on stationary missiles at the National Laser Test Range (White Sands, N.M.) in order to learn what level of laser energy is needed to destroy boost-phase missiles.

Chemical lasers were the basis of one of the first strategic defense concepts. In 1979, TRW, Lockheed, Perkin-Elmer, and Draper Laboratories proposed an array of orbiting battle stations that they claimed would be able to defend against a full-scale Soviet attack. Their plan, dubbed Alpha, called for 18 such stations, each carrying a 5-megawatt laser and a 4-meter-diameter mirror to focus the beam on an attacking missile for the several seconds needed to destroy it. Alpha's supporters claimed that their battle stations could be operational during the 1990s.

When it became clear that the Soviets could increase their missiles' damage threshold a hundredfold by applying heat-resistant coatings, attention shifted to advanced versions of Alpha, with 25-megawatt lasers and 15-meter mirrors (a larger mirror can focus a beam to a smaller point). Then, in April 1984, an SDI review panel headed by former NASA administrator James Fletcher cast doubt on the feasibility of fabricating such large mirrors. The Fletcher panel calculated that in order to produce a beam of high enough quality to travel the requisite 4000 kilometers, the mirror would have to be shaped to an accuracy of a fiftieth of a wavelength, or roughly 0.1 micron. A 15-meter mirror built to the much looser tolerances that are currently achievable, the panel said, would produce a

beam with such serious imperfections that it could be effective as a weapon over a range of only a few hundred kilometers—virtually useless for missile defense.

As an alternative to huge mirrors, the Fletcher panel borrowed an idea from the microwave world and proposed that a number of MIRACL-like lasers be assembled as a "phased array." Controlling the phase of each beam would produce the optical equivalent of a single very large beam, which could be focused to a small point. The phased-array chemical laser has yet to be demonstrated, however.

There is a more likely solution to the need for prohibitively large optics: shift to a shorter wavelength. The mirror diameter needed to attain a given beam quality decreases in proportion to wavelength; thus, shifting from infrared to the visible or ultraviolet region of the spectrum would reduce the required mirror size severalfold. One possibility is the iodine-fluorine laser. In theory this laser should operate at about 0.6 micron. But the laser's chemical formula—IF—tells the story. "It's very iffy," says Louis Marquet, who heads SDI's directed energy programs. "On paper it looks promising, but it hasn't lased yet."

Short-wavelength light has another important advantage besides permit-

*"We're well aware that current technology can't do the job."
—Gerold Yonas, chief scientist
for the Strategic Defense Initiative*

ting smaller optics: It is a more potent weapon, both because it can be focused to smaller spots and because it is better absorbed by most materials, including the aluminum, steel, and titanium commonly used to build missiles and aircraft. Stainless steel, for example, absorbs only about 20% of infrared light at the HF laser wavelength of 2.7 microns, with the rest being reflected harmlessly. The same material soaks up close to 40% of ultraviolet light.

The ultraviolet source with the greatest weapon potential, in the near term at least, is the excimer laser. These systems use an electron beam to produce energetic molecules comprising atoms of a rare gas (krypton or xenon) and a halogen (fluorine or chlorine). The result is an unstable compound such as krypton fluoride, which releases an ultraviolet photon and immediately breaks apart.

Excimer lasers require electrical power, and lots of it; only a small per-

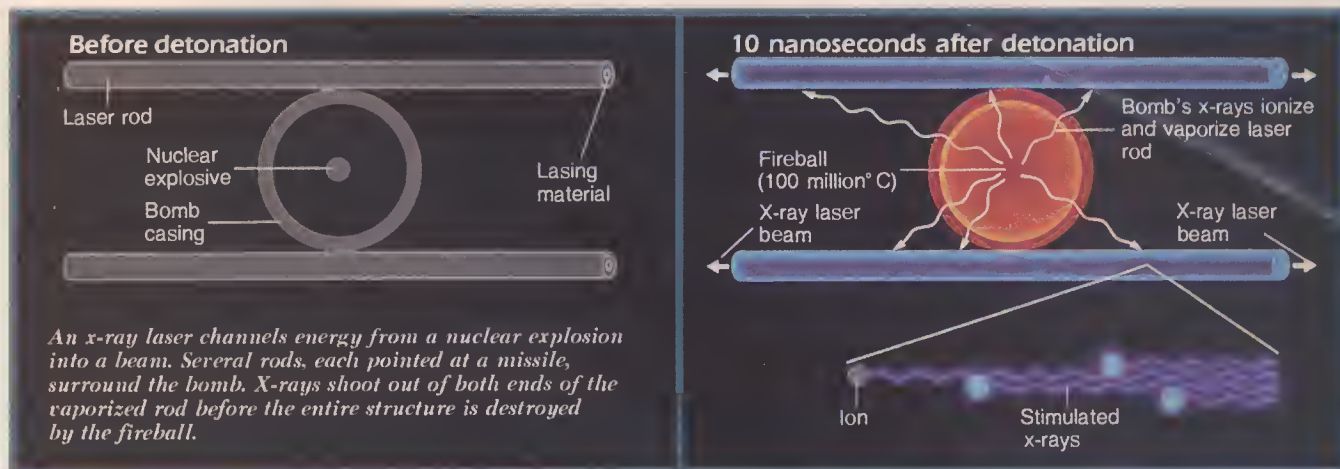
centage of the energy fed into the laser makes it out in the beam. Thus there is little interest in basing such lasers in space. Instead they would be kept on the ground, with their beams relayed to the target via orbiting mirrors. However, the journey through the atmosphere would rob the laser beam of much of its destructive potential; turbulent airflow aberrates and defocuses the beam, just as it does starlight.

The solution being pursued is "adaptive optics" (HIGH TECHNOLOGY, Sept. 1984, p. 12), which physicist Edward Teller calls "taking the twinkle out of a star." It stands as one of the trickiest problems in the SDI. The idea is to bounce the beam off a special deformable mirror that continually changes shape. Ideally, the mirror imposes aberrations on the beam that are exactly opposite to those that the atmosphere would introduce. This pre-aberrated beam is then "healed" by the atmosphere on its trip to space and arrives at the orbiting mirror in pristine form.

Even if adaptive optics proves feasible, however, excimer lasers face other problems. The same increased optical absorption that makes UV light so deadly to an enemy target also hinders the beam's transmission through the atmosphere. Thus "long wavelengths give better propagation, short wavelengths give better kill," says Jack D. Dougherty, vice-president for strategic defense programs at Avco-Everett Research Labs (Everett, Mass.), SDI's lead contractor for excimers.

For the same reason, optical components are more easily damaged by UV than by longer wavelengths. Excimer lasers therefore pose a severe threat to their own mirrors. The SDI program is seeking new materials and coating techniques that will yield more rugged mirrors, but progress has been discouragingly slow. Some 98% of the samples tested fail catastrophically, according to James Stanford of the Naval Weapons Center (China Lake, Cal.). Thin-film coatings for high-energy lasers are still "hit-and-miss," says Stanford, who coordinates SDI's optical materials research. He suggests in frustration that the optics community "petition Mother Nature for a break so we can get a UV laser that doesn't shoot itself in the foot."

The largest excimer laser in the SDI program is Avco's 5-kilojoule xenon fluoride system. Higher energies are thought feasible; both Avco and Western Research (San Diego) have designed systems capable of emitting 1-megajoule pulses. These lasers would kill by shock rather than burning—working "like a sledgehammer instead of a blow-



torch," says Keyworth—and would be immune to the simple countermeasure of spinning the booster rocket. Avco aims by 1990 to complete development of another excimer laser, which will put out smaller pulses at a clip of about 50 per second. Such a laser would inflict damage like a continuous beam.

Particle beams are considerably farther away from being used as functional weapons than are lasers. Since the particles cannot penetrate the atmosphere, the system must be based in space. But particle accelerators are large, power-hungry devices: A 10-megawatt beam would require a generator to burn fuel at 10 kilograms per second. In addition, it would be difficult to ascertain that the beam had done its job of destroying a missile's electronics; the loss of guidance would not become obvious immediately. Unable to verify a kill, a particle beam system might continue shooting at a disabled target—while other missiles proceeded unchecked. Also, while laser beams reflect off their targets, particle beams do not, making them much more difficult to aim.

Still, particle beam technologies are being pursued at a number of facilities. The Los Alamos, Livermore, and Sandia national laboratories have

decades of experience designing and building accelerators for research purposes; these labs now appear eager to attach themselves to the strategic defense bandwagon. For example, last April at a University of Rochester symposium on beam technologies, a representative from each lab took turns explaining to the gathered scientists and officials the advantages of his lab's particular accelerator technology for SDI.

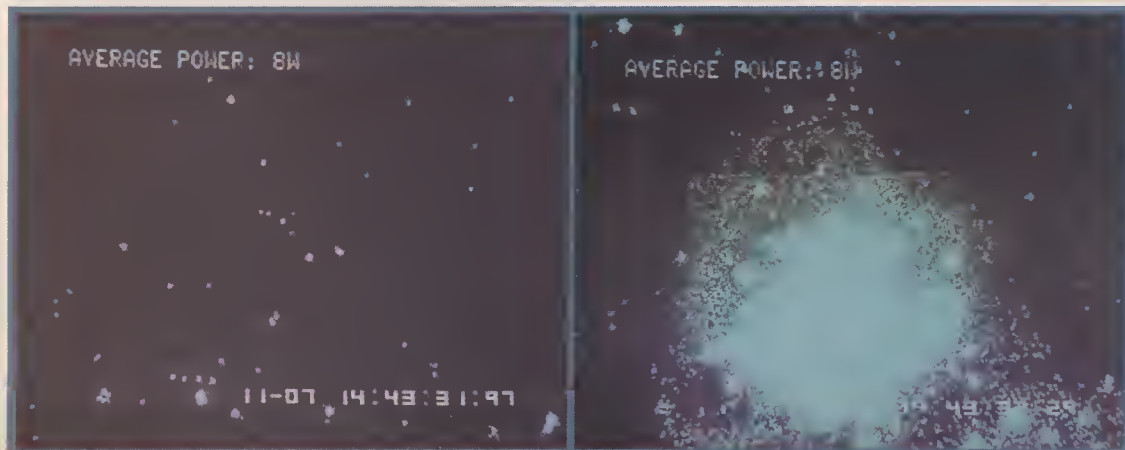
The key characteristic of any beam weapon is its "brightness"—defined as its energy divided by the solid angle at which it diverges. Present accelerators can attain the brightness believed to be necessary for an electronic kill, the Fletcher panel concluded. Another five orders of magnitude improvement would be needed for a particle beam to inflict structural damage similar to that from a laser, says Robert Jameson, who heads the accelerator technology division at Los Alamos.

One of the most important developments is the radio-frequency quadrupole (RFQ), being developed at Los Alamos as part of the White Horse program. The RFQ uses electric fields to keep negative hydrogen ions tightly bunched as they accelerate. In a weapons system, these ions would be further boosted in a linear accelerator (lin-

ac). Finally, they would be passed through a rarefied gas to remove their extra electrons. The resulting beam of neutral atoms could travel long distances in space without being deflected by the earth's magnetic field.

The RFQ, a Soviet invention, consists of a lightweight 2-meter-long tube that replaces the large, bulky magnets needed to focus the beam in conventional accelerators. Not only is the RFQ more compact than magnetic accelerators, but it also produces a higher-quality beam; the device "makes neutral particle beams viable" for SDI, says directed energy program director Marquet. The Soviets have been silent on RFQ technology of late, indicating to U.S. officials that they too are interested in weapons applications.

Not all particle beam work involves neutral beams. Experimental programs are under way at modest funding levels to explore the feasibility of directed energy weapons based on electron beams. Sandia is studying the propagation of such beams in the atmosphere. The idea is that a ground-based electron accelerator could zap warheads during their "terminal" stage of flight, as they descend from space toward their targets. Such warheads might be "salvage fused" (triggered to detonate upon in-



Laser weapons require sturdier optics than are now available. A tiny defect on a mirror (bright point, left) flares into extensive damage after 30 shots.



Chemical laser (above) is powered by the combustion of stored gases and therefore needs no electrical power; a more compact version is proposed for basing in space. The radio-frequency quadrupole (left) uses microwaves to focus ions into a tighter beam than is attainable with conventional particle accelerators.

terception); a powerful electron beam fired from the ground, however, could kill the warhead's electronics so quickly that the bomb would not go off.

As an electron beam travels, it ordinarily spreads out because of mutual repulsion by the negatively charged electrons. But Livermore is pursuing the possibility of using a laser to guide the electrons. The laser beam would ionize molecules in the earth's rarefied upper atmosphere, carving a channel of positive charge that would contain the electrons. The concept looks promising; the Defense Department is requesting \$30 million for the program developing it (called *Antigone*) in fiscal 1986, up from \$7 million in 1985.

Electron accelerators also form the basis of an entirely different type of directed energy system, the free-electron laser. The electrons are made to pass through a closely spaced set of magnets whose north and south poles alternate. As the electrons move back and forth through this "wiggler," they emit laser light.

In principle, such a device could produce megawatts of power at any wave-

length, while operating at efficiencies of up to 30%. To date, however, the free-electron laser has been built only in small-scale experimental versions. The Los Alamos design, for example, has operated only in the infrared region—at wavelengths of 9–35 microns—and with an efficiency of about 1%. Work on an ultraviolet free-electron laser has so far yielded only low power.

Given the difficulties with lasers and particle beams, it is little wonder that the near-term prospects for the SDI involve an entirely different class of devices called kinetic energy weapons. The idea is to hurl an object at the target with enormous speed. At five miles per second, a projectile's energy of motion gives it a punch equal to six times its weight in TNT. These heat-seeking "smart rocks" would probably be based in satellites; they would be fired with electromagnetic cannon called rail guns, or with rocket engines. Smart rocks made the news in June 1984 when the Army announced that a kinetic energy weapon had made a direct hit on a Minuteman ICBM warhead.

Powerful beams or fast-moving projectiles, although critical to Star Wars, would not be sufficient to make the program work. Indeed, one could say that the SDI is no more about beam weapons than the Normandy invasion was about howitzers. Of critical importance are such tasks as tracking the missiles, identifying warheads amidst a cloud of decoys, and verifying their destruction. Half the SDI budget for the rest of the decade will go toward computer and communications research for what defense planners call battle management.

Even in the most optimistic projections, a fully functioning defense system will not be achieved for decades. "We're well aware that current technology can't do the job," says SDI chief scientist Gerold Yonas. Accordingly, the next five years or so will be dedicated to research; the goal is to gain enough knowledge on a variety of technologies to allow an informed decision in the early 1990s on whether defense against nuclear attack is feasible.

If the answer is yes, building and demonstrating prototypes of defense systems would likely occupy the remainder of the century. Finally there would come a decision on whether to deploy. But although research on defense systems is permitted by the 1972 Anti-Ballistic Missile treaty, deployment is not.

Thus critics point out that SDI would violate an important treaty. Moreover, they say, it would have to be 100% effective—a virtually impossible goal—and it would be destabilizing. The superpowers could respond to each other's defense efforts by building more and better offensive arsenals; or, in response to U.S. plans for deployment of a defense system, the Soviets might be tempted to attack before their missiles became useless.

SDI officials insist that the defensive shield need not be leakproof to fulfill its purpose, which is to deter attack. Thus an imperfect defense could still be effective if it made the requisite offensive buildup by the Soviets prohibitively expensive. SDI proponents also argue that after the admittedly tricky period of transition, strategic defense would relieve the hair-trigger sensitivity of nuclear deterrence. If there is a major crisis and someone pushes the nuclear button, the world might be destroyed. But if anyone pushes the laser button, even in error, the worst result would be beams dissipating harmlessly in the atmosphere. □

T. A. Heppenheimer, a writer in Fountain Valley, Cal., has a PhD in aerospace engineering.



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Corporations get on the "Star Wars" beam

If the Reagan Administration has its way, the Strategic Defense Initiative (SDI) will spend \$32 billion between fiscal years 1985 and 1990 in research programs intended to establish the feasibility of technical options for ballistic missile defense. Funds for directed energy weapons would total some \$6 billion during this initial stage. Such devices would be allocated almost \$1 billion of the \$3.7 billion requested for SDI by the administration for FY 1986, with an equivalent amount going to kinetic energy weapons and most of the remainder to work on surveillance, command, and control systems.

Within the directed energy sector—an area in which the major players will be defense contractors—ground-based lasers receive \$432 million, space-based lasers \$372 million. Work on nuclear-directed x-ray lasers (\$29 million requested, with additional funding from the Department of Energy) and particle beam weapons (\$134 million) is carried out largely at Los Alamos and other national laboratories.

The Pentagon has only begun to let out SDI contracts, but they are not for everyone. Even at this early stage of SDI, "the directed energy field is probably sewn up by companies that were involved during the pre-SDI period," says John Bosma, editor of the *Military Space* newsletter (Arlington, Va.). In addition, he says, "significant capitalization is required to play in this field, and the expertise needed is not widely available."

Companies prominent in energy weapons-related research are concentrated among the large aerospace and defense electronics firms. Chemical lasers are being developed by Rockwell International's Rocketdyne Div. (Canoga Park, Cal.), which has been working since the mid-1970's with a high-energy laser code-named Sigma Tau, and by TRW's Electronics and Space Systems Div. (Redondo Beach, Cal.), which has worked on two devices—the Alpha laser, based on a cylindrical design similar to that of Sigma Tau, and the Mid-Infrared Chemical Laser. Textron's Avco Everett Research Laboratory (Everett, Mass.), whose connection with laser weapons goes back to the 1960s, is a prime contractor for excimer lasers.

Lockheed Missiles and Space Co. (Sunnyvale, Cal.) is a prime contractor for



**David Smith,
Defense
Analyst,
Stanford C.
Bernstein**

"The need to integrate sensors with SDI is driving research on high-speed signal processing, which aerospace companies hope to leverage into improvements in manufacturing productivity and telecommunications."

a program on target acquisition, tracking, and pointing (Talon Gold) and a program to develop a mirror for focusing laser beams (the Large Optics Demonstration Experiment). And Litton's Itek Optical Systems (Lexington, Mass.) has applied its extensive experience in adaptive optics to laser contracts. Additional laser work is underway at Science Applications International (La Jolla, Cal.), Westinghouse Electric (Pittsburgh), and

"Small-business opportunities in directed energy devices and other advanced research programs often involve helping the government select the right technology for a particular application."

**Robert Sepucha
VP for Space Technology
W. J. Schafer Associates**

Hughes Research Laboratories (Malibu, Cal.)—a subsidiary of Hughes Aircraft whose recent acquisition by General Motors plunged the automaker directly into the Star Wars universe.

Smaller firms may also be found in the

directed energy arena. For example, BDM International (McLean, Va.) provides support services to the Army's High Energy Laser System Test Facility and is developing hardware and software for laser beam control. Logicon (Torrance, Cal.) consults on laser evaluation and weapons integration, and W. J. Schafer Associates (Washington, D.C.) is working on free electron lasers and beam control. But it is possible that the role of smaller firms will diminish as the SDI budget grows. Julius Feinleib, president of Adaptive Optics Associates (Cambridge, Mass.), fears that larger corporations will increasingly undertake technological work in-house instead of turning to innovative subcontractors.

In any case, companies seeking business opportunities from SDI might do well to look beyond directed energy, says David Smith, defense analyst with Stanford C. Bernstein (New York). One alternative, he says, is kinetic weapons—"the least expensive and most proven technology" among SDI's options.

John Bosma stresses that the non-weapons components of SDI—surveillance, tracking, and battle management systems—will offer reliable contract opportunities because they will be needed regardless of what types of defensive systems emerge. For example, precision guided kinetic energy or laser weapons will have to be able to discriminate reentry vehicles from decoys, a requirement that will stimulate work in advanced imaging sensors, real-time signal processing, new software development tools, and very-high-speed integrated circuits (VHSICs). "These are precisely the kinds of fields," says Bosma, "in which fast-moving, entrepreneurial companies have traditionally excelled."

Beyond the short-term opportunities provided by SDI contracts, the program's ultimate appeal to many companies is the funding being made available for research that will drive the next generation of technology in such fields as optical computers, composite materials, and space-based power systems. "Without something like an SDI," says Adaptive Optics' Feinleib, "this country doesn't have a good mechanism for supporting advanced technologies that enable us to compete with Japan and other countries."

—Dennis Livingston



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PERSPECTIVES

Spreading the government's technological wealth

Each year, the U.S. government sponsors some \$55 billion of R&D and produces more than 50,000 patents and technical reports. Relatively little of this technological wellspring is ever tapped by the private sector; indeed, few companies are fully aware of the available bounty. Over the past two years, however, a little-known agency—the Center for the Utilization of Federal Technology (CUFT)—has made impressive strides toward bringing the fruits of government research into the hands of business.

Although created by the Stevenson-Wydler Technology Innovation Act of 1980, CUFT began action only in 1983, as an arm of the Commerce Department's National Technical Information Service (NTIS). Its main role is to disseminate information and to nudge federal laboratories toward greater consciousness of their work's commercial potential, says Edward Lehmann, director of the center's applied technology office. "We want them to ask, 'What happens to R&D when it is finished?'" Some federal organizations, like NASA, vigorously promote such spinoff on their own. CUFT has therefore concentrated its efforts on other agencies, such as the National Institutes of Health (NIH) and the National

Bureau of Standards.

Some critics argue that government technology is largely irrelevant to industry, citing a much quoted statistic from the early 1970s showing that only 4-5% of all federal patents were licensed commercially. But newer figures contradict that criticism, says David Mowry, the NTIS associate director who heads CUFT. During fiscal year 1984, he says, almost 30% of federal patents were licensed—similar to the rate for university and industry patents.

Not all of that improvement can be attributed to CUFT's efforts at streamlining the transfer of technology. Another factor has been the revision of government patent policy to allow a company, under certain conditions, to negotiate an exclusive license for a federally owned invention. Freed from the threat of immediate competition, the company is more willing to spend money developing the technology.

"Very rarely are there plums waiting to be picked," says Lehmann. "The successful user is going to have to do some work on his own." He estimates that companies will spend \$144 million for further development of the 44 patents licensed through CUFT last year.

A typical example is Orange Medical

Instruments (Costa Mesa, Cal.), which first learned in 1982 about new fiber optic devices developed by NIH to measure pH and carbon dioxide. The company quickly acquired a license. But the first sensors won't hit the market until late this year, according to executive vice-president Ken Hughes; the company had to spend two years making the electrodes more reliable and refining manufacturing techniques.

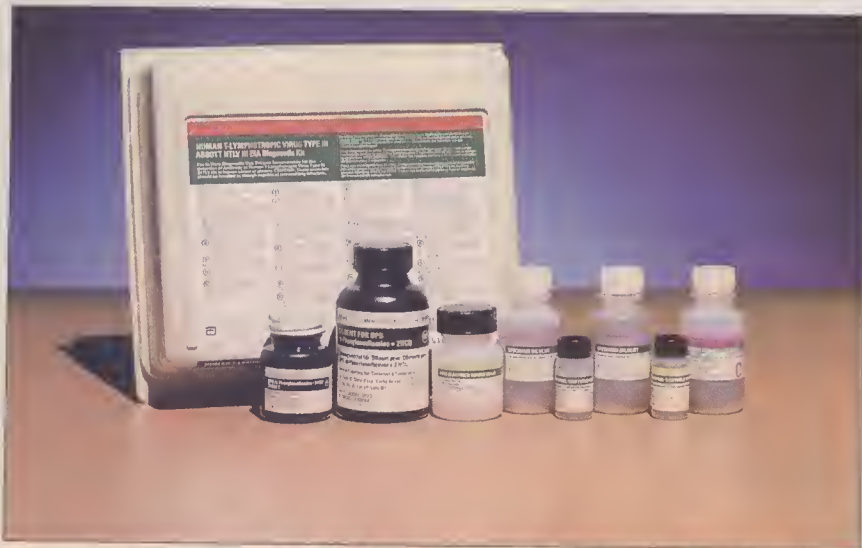
Less development was needed for a new technology for making concrete. The Bureau of Mines had set out to find new uses for sulfur, which is a perennial glut on the market. The bureau's researchers discovered that substituting sulfur for portland cement yielded a high-strength, acid-resistant concrete. The process was patented, but the technology sat on the shelf for several years, in part because exclusive licenses were not then available.

Scott Pickard was an engineer at a construction firm when he read details of the process in a journal. He secured a license (for \$500), quit his job, and started a company called Sulcon (Champaign, Ill.) to pour acid-resistant concrete floors in chemical plants. Pickard expects the company's revenues this year to be double the \$900,000 taken in last year. The license is partially exclusive—only one other company can make the concrete—so Sulcon expects to tap a large share of the potential \$60-100 million U.S. market for the service.

Occasionally an invention leaps from a government lab into a company's product line almost unchanged. Last year, when scientists at NIH developed assays to screen blood for the presence of viruses related to AIDS, "the technology practically sold itself," according to Norman Wald, manager of technology assessment at Abbott Laboratories (North Chicago, Ill.). Because of the intense concern about AIDS, moreover, the licensing process was expedited; by this past spring, Abbott and four other companies were marketing the assays.

CUFT puts out information in several formats:

- Monthly Tech Notes, which pro-



NIH development work led to a kit to screen blood for AIDS-related antibodies: "The technology practically sold itself."

vide one- or two-page fact sheets describing new processes, equipment, materials, and techniques. They are available in ten subject areas: computers, electrotechnology, energy, engineering, life sciences, machinery and tools, manufacturing, materials, physical sciences, and testing and instrumentation. \$60/year per subject area.

- A weekly newsletter containing abstracts of patents. \$205/year.

- *Federal Technology Catalog*, a yearly summary of the information in *Tech Notes*. \$23.50.

- *Catalog of Government Patents*, a yearly summary of patents available for licensing. \$25.

- *Catalog of Federal Technology Resources*, a summary of government facilities, services, information centers, and expertise. \$25.

In addition, the databases from which these publications are drawn are available for computer search. For further information, contact Center for the Utilization of Federal Technology, Room 8R, National Technical Information Service, Springfield, VA 22161, (703) 487-4838. □

—Thomas H. Maugh II

Garbage in, energy out

As cities run out of room for their refuse, incineration is an increasingly attractive option: Burning trash reduces its volume and generates energy besides. And lately, cities are enjoying the luxury of choosing between two fundamentally different incineration technologies that are competing for their business.

In a "mass-burn" incinerator, everything that is trucked in, from rotting scraps of food to highly processed paper and metal, is simply dumped into a boiler and used as fuel. The steam drives generators, and the electrical power is sold to local utilities. The ash is then sent to landfill.

Advocates of mass burn cite the technology's maturity (it has long been used in Europe and Japan), simplicity, and proven ability to attract financing. New York City, the world's biggest

trash producer, is considering a plan to build eight mass-burn incinerators at a cost of \$2.5 billion.

But an alternative method is capturing a growing share of the developing market for municipal waste incineration. A "prepared-burn" plant operates on the premise that some trash, such as paper and metal, is worth more as raw material than as fuel. The waste stream is thus culled to remove potentially valuable materials. Ferrous metals are pulled out magnetically. Minerals are separated by specific gravity in a system similar to the jig-sorter used in mining. Nonferrous metals such as aluminum and copper are pulled out by hand. What remains is shredded into a fuel that fires a boiler.

Not only does the plant produce revenue from the energy produced, but it can also make money on the resources recovered. A prepared-burn incinerator now operates at the world's largest solid waste facility, a 3000 ton/day plant in Miami. Each week, the plant recovers and sells 800-1000 tons of ferrous metal and 45 tons of aluminum—not to mention \$1000 worth of coins—according to George Boyhan, senior vice-president of Resource Recovery Inc., which runs the facility. Ash from the incinerator is sold as an additive for cement.

Culling the waste stream also cuts down on the volume of ash that must be buried. Boyhan estimates the residue from the Florida incinerator is about 10% of the volume of the raw waste stream. A typical mass-burn system, by contrast, leaves a pile of ash about a quarter the size of the original refuse.

The amount of preparation varies from plant to plant. The simplest "crunch and burn" facilities take out only the metal. But the trend is toward more extensive recycling. For example, an incinerator run by Sorain Cechini in Rome, Italy, blows air through the trash to separate light materials; paper is removed for making pulp, polyethylene for making PVC pipe or plastic bags. After a series of such separations, the remaining waste materials are sold as fuel for cement kilns in Perugia.

Early prepared-burn plants failed to demonstrate the economies that their

developers had predicted; the sale of recovered resources barely paid for the cost of separation. But Harvey Funk of Raintree Resource Recovery (Houston), which has designed both types of incinerators, claims that prepared burn's reputation for high cost is unearned. The cost of building either type runs about \$60,000-\$85,000 per ton of capacity, he says, but fewer prepared-burn plants are needed to process a given amount of waste. New York could handle its trash with three prepared-burn incinerators and 15-20 processing centers instead of the eight mass-burn units now planned, according to Funk. And a prepared-burn plant is a superior energy generator, he says, because it can use smaller, more efficient furnaces.

Reduction of pollution may be another advantage of prepared burn. There is evidence that the burning of chlorinated (hard) plastics together with paper generates the toxic class of compounds known as dioxins. Mass-burn advocates claim that the high temperatures in their boilers (up to 2000° F) break down whatever dioxins are formed. Data from these incinerators have shown little relationship between burn temperature and dioxin production, however.

It is possible that dioxins are produced not in the boiler but in the cool stacks, where the carbon from the paper combines with the chlorine from the plastic. The chief proponent of this theory, Barry Commoner of the Queens Center for the Biology of Natural Systems (New York), says that mass-burn incinerators of any temperature are "factories for producing dioxins." A prepared-burn plant that removed paper for recycling would presumably alleviate the problem.

Still, by far the largest player in the incinerator business—the \$6-billion-a-year conglomerate Signal (La Jolla, Cal.)—is sticking with mass burn. Ideally, valuable materials like glass, paper, and metal would not enter the waste stream to begin with, says Ronald Broglio, Signal's vice-president for operations; once mixed in with unrecoverable trash and garbage, they are too expensive to remove. "If prepared burn were economical," he says, "we would do it." □ —Bruce D. Stutz

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RESOURCES

Following are sources for further information about topics covered in the feature articles in this issue.

Japan's technology agenda

Industrial policy, p. 24

Science & Technology in Japan. Three "I" Publications, Kamakuracho Parking Bldg., 1-5-16, Uchikanda, Chiyoda-ku, Tokyo 101, Japan; tel (03) 291-3761. Published in cooperation with the Science & Technology Agency.

Science and Technology in Japan. Alun M. Anderson. Essex, England: Longman Group, 1984. A comprehensive survey.

Japan. Hugh Sandeman. London: Economist Newspaper Ltd., 1983. A collection of articles written for *The Economist*.

"How Japanese industrial policy works." Robert S. Ozaki. *The Industrial Policy Debate*, ed. Chalmers Johnson. San Francisco: Inst. for Contemporary Studies, 1984.

"Industrial Policy, Part I: The Japanese Model." *Manhattan Report on Economic Policy*, Oct. 1982. Includes interviews with Japan-watchers Hugh Patrick and Thomas Pepper.

"MITI's guidance of nation's industry looks enigmatic and tricky to foreigners." Kiyoo Suda. *Industrial Review of Japan* 1984. Published by the *Japan Economic Journal*.

"Looking behind Japan, Inc." Richard J. Samuels. *Technology Review*, July 1981.

"Japanese strategies for dealing with 'technological blockade.'" Donald L. Philippi. *Japan Intelligence*, Feb. 1, 1985.

"Japan focuses on basic research to close the creativity gap." *Business Week*, Feb. 25, 1985.

"The new face of Japanese science." John Bell et al. *New Scientist*, Mar. 21, 1985. Review of Japanese R&D, with spotlights on specific research projects.

Cameras, p. 33

"Autofocus looks sharp." Ctein. *High Technology*, Nov./Dec. 1983. Overview of autofocus techniques.

"Minolta's Maxxum: an autofocus SLR system that really works." Bob Schwalberg. *Popular Photography*, March 1985. Technical review of Maxxum camera, lenses, and autofocus.

7000 Technical Profile. Minolta, 30, 2-chome, Azuchi-Machi, Higashi-Ku, Osaka 541, Japan. Technical report on Maxxum camera and options (in Japanese).

"PMA '85: the shape of things to come." Arthur Goldsmith. *Popular Photography*, June 1985. Roundup of new cameras and other equipment at the 1985 Photographic Marketing Association trade show.

Automobiles, p. 36

Contacts

Japan Automobile Manufacturers Ass'n (JAMA), 1050 17th St., NW, Wash., DC 20036; tel. (202) 296-8537.

Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096; tel. (412) 776-4841.

References

The Motor Industry of Japan. JAMA, 1985. Statistical summary of Japanese auto industry manufacturing, domestic consumption, and exports for 1984.

The American and Japanese Auto Industries in Transition: The Report of the Joint U.S.-Japan Automotive Study. SAE, 1984. Report on consumer demand, manufacturing systems, auto technology, and internationalization.

Report of the Tenth International Technical Conference on Experimental Safety Vehicles, July 1-5, 1985, Oxford University, England. Several papers by Japanese engineers on four-wheel drive and four-wheel steering.

"Toyota's new single-chip microcomputer-based engine and transmission control system." Tohru Takahashi et al. 1985 SAE Int'l Congress, paper #850289.

"Assimilating Japanese technological progress." Bruce Rubinger. 1985 SAE Int'l Congress, paper #850340.

Optoelectronics, p. 39

Contacts

Engineering Research Association of Optoelectronics Applied System, No. 20 Mori Bldg., 5th Fl., 7-4, Nishi-Shinbashi, 2-chome Minato-ku, Tokyo 105, Japan; tel. (03) 508-0311.

Optoelectronics Joint Research Laboratory, 1333, Kami-Odanaka, Nakahara-ku, Kawasaki City, Kanagawa Prefecture 211, Japan; tel. (044) 711-0311.

Reference

Optoelectronic Project. Pamphlet available from the Association address above.

Semiconductors, p. 46

"Japanese research takes aim at U.S. hold on chip design." Peter Osterlund. *Christian Science Monitor*, Apr. 1, 1985.

"Sun rises on new designs." Charles L. Cohen. *Electronics Week*, Mar. 4, 1985.

"Chip wars: Japanese threat." *Business Week*, May 23, 1985.

Ceramics, p. 50

Ceramic Soc. of Japan, Shinjuku-ku, Hyakunin-cho, 2-22-17, Tokyo 160, Japan.
Japan Fine Ceramics Ass'n, Minato-ku,

Toranomon, 11-22-13, Nishikan-Toranomon Bldg., Tokyo 105, Japan.

Biotechnology, p. 53

Commercial Biotechnology: An International Analysis. Office of Technology Assessment. Publication OTA-BA-218, Jan. 1984. U.S. Govt. Printing Office, Wash., DC 20402. Includes comparisons of national strengths and weaknesses in bringing biotech to market.

Consumer electronics, p. 59

Japan Electronic Industry Development Association (JEIDA), Kikai Shinko Bldg., 3-5-8, Shibakoen Minato-ku, Tokyo 105, Japan; tel. (03) 434-8211; telex JEIDA J27544.

Japan Electronics Show Association, Tokyo Chamber of Commerce Industry Bldg., 3-2-2, Marunouchi, Chiyoda-ku, Tokyo 105, Japan. Organizers of the Japan Electronics Show, 1985, which emphasizes consumer electronics.

Computers, p. 63

Contact

Institute for New Generation Computer Tech. (ICOT), Mita Kokusai Bldg. 21F, 1-4-28, Minato-ku, Tokyo 108, Japan; tel (03) 456-2511; telex ICOT J32964.

References

Outline of Fifth Generation Computer Project. Available from ICOT.

ICOT Journal. Available from ICOT.

"Supercomputers: High-tech's superpowers put reputations on the line in a race to build the world's fastest computers." Peter Osterlund. *Christian Science Monitor*, Apr. 16, 1985.

"Hitachi CPU challenges IBM." Charles L. Cohen. *Electronics Week*, Mar. 18, 1985.

Micro peripherals, p. 66

"What future for microcomputers from Japan?" Susumu Aizawa, Epson. *ASCI*, Apr. 1985.

Particle beam weapons, p. 72

"Weapons in space." *New York Times* series, Mar. 3-8, 1985.

"Space-based ballistic-missile defense." Hans A. Bethe et al. *Scientific American*, Oct. 1984.

"Laser weapons." Kosta Tsipis. *Scientific American*, Dec. 1984.

Beam Weapons: The Next Arms Race. Jeff Hecht. New York: Plenum, 1984. Balanced account of the technologies and problems.

"Space-based lasers." Wallace D. Henderson. *Astronautics & Aeronautics*, May 1982.

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 () 2. Specify
 () 3. Approve

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Science and Techn
Anderson. Ess
Group, 1984. A c
Japan. Hugh Sar
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of articles writte

"How Japanese i
Robert S. Ozak
Debate, ed. Chal
cisco: Inst. for
1984.

"Industrial Policy
Model." *Manha*
Policy, Oct. 19
with Japan-wat
Thomas Pepper.

"MITI's guidance
enigmatic and
Kiyoo Suda. *Inc*
1984. Published
Journal.

"Looking behind
J. Samuels. *T*
1981.

"Japanese strateg
nological blocka
Japan Intelligen

"Japan focuses on
the creativity g
25, 1985.

"The new face of
Bell et al. *New*
Review of Japan
on specific resea

Cameras, p. 33

"Autofocus looks s
nology, Nov./De
focus techniques.

"Minolta's Maxxum: an autofocus SLR sys-
tem that really works." Bob Schwalberg.
Popular Photography, March 1985. Techni-
cal review of Maxxum camera, lenses,
and autoflash.

7000 *Technical Profile*. Minolta, 30, 2-
chome, Azuchi-Machi, Higashi-Ku, Osa-
ka 541, Japan. Technical report on
Maxxum camera and options (in
Japanese).

"PMA '85: the shape of things to come."
Arthur Goldsmith. *Popular Photography*,
June 1985. Roundup of new cameras and
other equipment at the 1985 Photograph-
ic Marketing Association trade show.

Optoelectronic Project. Pamphlet available
from the Association address above.

Semiconductors, p. 46

"Japanese research takes aim at U.S. hold
on chip design." Peter Osterlund. *Chris-
tian Science Monitor*, Apr. 1, 1985.

"Sun rises on new designs." Charles L. Co-
hen. *Electronics Week*, Mar. 4, 1985.

"Chip wars: Japanese threat." *Business*
Week, May 23, 1985.

Ceramics, p. 50

Ceramic Soc. of Japan, Shinjuku-ku, Hy-
akunin-cho, 2-22-17, Tokyo 160, Japan.
Japan Fine Ceramics Ass'n, Minato-ku,

Particle beam weapons, p. 72

"Weapons in space." *New York Times* se-
ries, Mar. 3-8, 1985.

"Space-based ballistic-missile defense."
Hans A. Bethe et al. *Scientific American*,
Oct. 1984.

"Laser weapons." Kosta Tsipis. *Scientific*
American, Dec. 1984.

Beam Weapons: The Next Arms Race. Jeff
Hecht. New York: Plenum, 1984. Bal-
anced account of the technologies and
problems.

"Space-based lasers." Wallace D. Hender-
son. *Astronautics & Aeronautics*, May
1982.

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TECHSTARTS

Display Sciences:

PROJECTION VIDEO GOES CORPORATE

Videocassettes could easily replace movies and slide shows for business and classroom presentations—if it weren't so hard to see an ordinary television monitor in a crowded room. That's where projection video fits in. Display Sciences' \$3750 Lightbeam system combines a video projector, a 50-inch screen, a VHS cassette player and recorder, and a public-address system into a 30-pound unit the firm is selling to companies, schools, and institutions. Sony, its main competitor, markets a similar system, but with the Betamax cassette format rather than VHS. A stripped-down, 15-pound version of Lightbeam that handles 80-column computer displays is aimed at classes in programming. Display Sciences plans to sell both versions through a network of distributors.

Financing: \$5 million from the Clarendon Group, a Bermuda-based insurance conglomerate that includes the U.S. company General Reinsurance.

Management: Display Sciences is the latest joint entrepreneurial venture of president and CEO Peter Sprague and chairman Vincent Dono-

hue, who (with a third partner) formed the international trading company Dunhill Trading in 1982 and previously attempted to buy Ireland's premier movie studio, Ardmore Studios. Sprague has, since 1966, been chairman of National Semiconductor, a maker of integrated circuits and computer equipment. Donohue is founder of Arcturus, a service company for projection video systems. Previously he founded Speywood Communications, a distributor of video projection systems and developer of projectors for flight simulators. VP of Marketing David Parse was general sales manager of the consumer electronics company Quasar.

Location: 146 E. 56th St., New York, NY 10022, (212) 308-3334.

Founded: August 1984.

Intelligent Business Systems:

LET'S TALK NUMBERS—IN PLAIN ENGLISH

Most people associate artificial intelligence with the rarified atmosphere of research projects rather than down-to-earth applications like accounting. But an accounting system is exactly what Intelligent Business Systems (IBS) has connected to its Easytalk natural-language program; as a result, people can use English in place of structured programming commands to get information from an accounting database. Easytalk grew out of natural-language technology developed by Yale's artificial intelligence lab. IBS sells the program only as part of a complete accounting system, which includes a DEC minicomputer and Amcor Computer's accounting software. The company intends to adapt natural languages to other office applications in the future.

Financing: \$2 million in venture capital from investors including Prime Capital Limited Partnership and Regional Financial Enterprises.

Management: CEO William Bird was managing part-

ner of Bird and Co., a firm that helped corporate clients acquire computer service and software companies. He was previously president of Data Services, a subsidiary of ITEL. Steven Schwartz, VP of research and product development, was VP of software for Cognitive Systems. Before that, he was a research associate in Yale's AI lab.

Location: 246 Church St., Suite 201, New Haven, CT 06510, (203) 785-0813.

Founded: October 1983.

Enzon:

USING ENZYMES TO TREAT DISEASE

Enzymes could potentially be "magic bullets" in the war against disease. Their ability to catalyze chemical reactions lets them selectively break down harmful substances. Unfortunately, most injected enzymes pass out of the bloodstream quickly, and repeated injections can cause a lethal allergic reaction. Enzon has a process for attaching polyethylene glycol (PEG) strands to enzymes to "disguise" them and, it believes, eliminate allergic reactions. One such enzyme has been approved by the FDA for testing as a treatment for leukemia, and clinical trials began in April at a Houston hospital. Enzon has an exclusive license for the PEG process from its developers—VP Frank Davis and two others—and is already at work on several other enzymes.

Financing: \$450,000 in venture capital from private investors. \$4 million from an initial public offering, underwritten by Muller & Co. in February 1984, of 680,000 shares of stock at \$6 each (OTC: ENZN).

Management: Enzon's founders, president Abraham Abuchowski and VP of research Frank Davis, came from Rutgers University's biochemistry department, where the PEG process was developed. Prof. Davis continues to do research at Rutgers. VP of operations Richard Stone was an independent floor trader on the New York futures exchange and was previously a VP of W. R. Grace, in charge of its Davison division.

Location: 300C Corporate Ct., South Plainfield, NJ 07080, (201) 668-1800.

Founded: September 1981.



Display Sciences' Peter Sprague demonstrates the Lightbeam video projection system.

SEARCHING FOR THE PROMISED LAN

Lack of standardization inhibits growth of computer networks

After several years of gradual expansion, the market for local-area networks (LANs) is beginning to pick up momentum. LANs came on the scene in the late 1970s, promising to link different types of computers and nearby devices such as printers and disk drives together via cables. But despite the proliferation of microcomputers and the need to share expensive resources, only a modest business for local-area network suppliers has so far been generated.

Prospects are brightening now for several reasons. The continuing influx of PCs into businesses is increasing pressure on managers to install data communications links. Also, the price of the devices that connect computers and peripherals to the network cabling has dropped precipitously with the development of low-cost networking chips based on very-large-scale integration. IBM and AT&T, long-time bystanders to the marketplace, both announced LAN products last year, thereby lending their good names to the concept. And perhaps most important, the long-promised capability of LANs to link dissimilar computers is starting to be realized as vendors offer sophisticated protocol conversion software packages that operate over the networks. As a result, the *California Technology Stock Letter* estimates that LAN sales will grow from \$300 million this year to \$1.5 billion by 1987.

LAN growth would be even stronger if it weren't for a lack of industrywide standards. Many potential customers are inhibited by the possibility that a LAN investment they make today could be obsolete tomorrow. In factory automation General Motors has compelled vendors to work with a standard applicable to its facilities, but few cus-

tomers have that kind of buying power. In the meantime, the larger vendors such as IBM, DEC, Wang, AT&T, and Xerox are attempting to create de facto standards for the LAN market derived from their own proprietary network protocols, while over 40 smaller LAN vendors have emerged to offer supporting networking products and custom services.

Another complication in the market involves shifts in customer demand between the two types of network transmission. Broadband LANs offer multiple channels, allowing voice, data, and video to be sent simultaneously over the same cable; baseband LANs provide only one channel, for sending messages. Although baseband products are usually less expensive and have a larger installed base than broadband, the latter, with their greater communications capabilities, are increasingly popular.

LAN vendors have scrambled to keep up with changing customer preferences by diversifying their product lines and broadening their distribution outlets. In the search for additional sources of capital, several firms are going public or are looking to be acquired. While many of the public LAN companies have recently seen their overvalued stocks drop from previous highs, the three biggest companies among the smaller vendors—Micom (Simi Valley, Cal.), Ungermann-Bass (Santa Clara, Cal.), and 3Com (Mountain View, Cal.)—are of interest because their business strategies have been responsive to changes in networking markets.

Micom (OTC: MICS) sells a wide variety of communications equipment to customers who are mostly minicomputer users. The company is the largest player in the market for data private automated branch exchanges (PABXs), centralized data communications switching systems that have evolved from voice PABXs. Data PABXs can coexist with LANs. They are cheaper than LANs on an average per-connection basis but less flexible and more limited in network expansion capabilities.

In March, Micom acquired Interlan, one of the top three independent vendors of LANs for minicomputers. Micom now has the advantage of selling

baseband and broadband LANs to its installed base of data PABXs and being able to offer both LANs and PABXs to new customers.

Taking Interlan revenues into account, Micom had \$140 million in sales with earnings of \$1.22 per share in 1984; it climbed to \$193 million (with \$18 million coming from Interlan) and \$1.48 per share in fiscal 1985.

Ungermann-Bass (OTC: UNGR) is the biggest pure-play LAN company, with revenues of \$52 million in 1984, estimated to reach \$60 million in 1985, but with earnings expected to drop from 38¢ to 30¢ per share. The firm is diversified, manufacturing and selling baseband and broadband LANs for computers of all sizes. Ungermann sustained losses earlier this year because it did not anticipate that an upswing in demand for broadband products would be greater than it could fill, while baseband demand slackened. Having derived 30% of revenues from broadband products last year, Ungermann expects broadband to account for 50% of its revenues this year.

3Com (OTC: COMS) has been highly profitable in its narrow market niche. The company is a producer of baseband LANs derived from Xerox's Ethernet, which it sells to the microcomputer and workstation market, but over 80% of 3Com's revenues last year came from its adapter cards (an early-version LAN). Recently the company has been trying to diversify. Perceiving the trend toward broadband, and preferring to offer such a product as a result of an acquisition rather than from internal development, 3Com attempted in March to acquire Sytek, a supplier of broadband LANs and IBM's chosen source for its PC Network hardware. Negotiations were unsuccessful, but 3Com is continuing to pursue potential acquisitions while enjoying strong sales from its new network file server product.

In 1984, 3Com had sales of \$16.6 million and earned 19¢ per share. Revenues in the current fiscal year will likely top \$40 million, with earnings exceeding 30¢ per share. □

Lissa Morgenthaler is a security analyst at the California Technology Stock Letter, a San Francisco-based investment newsletter.

by Lissa Morgenthaler

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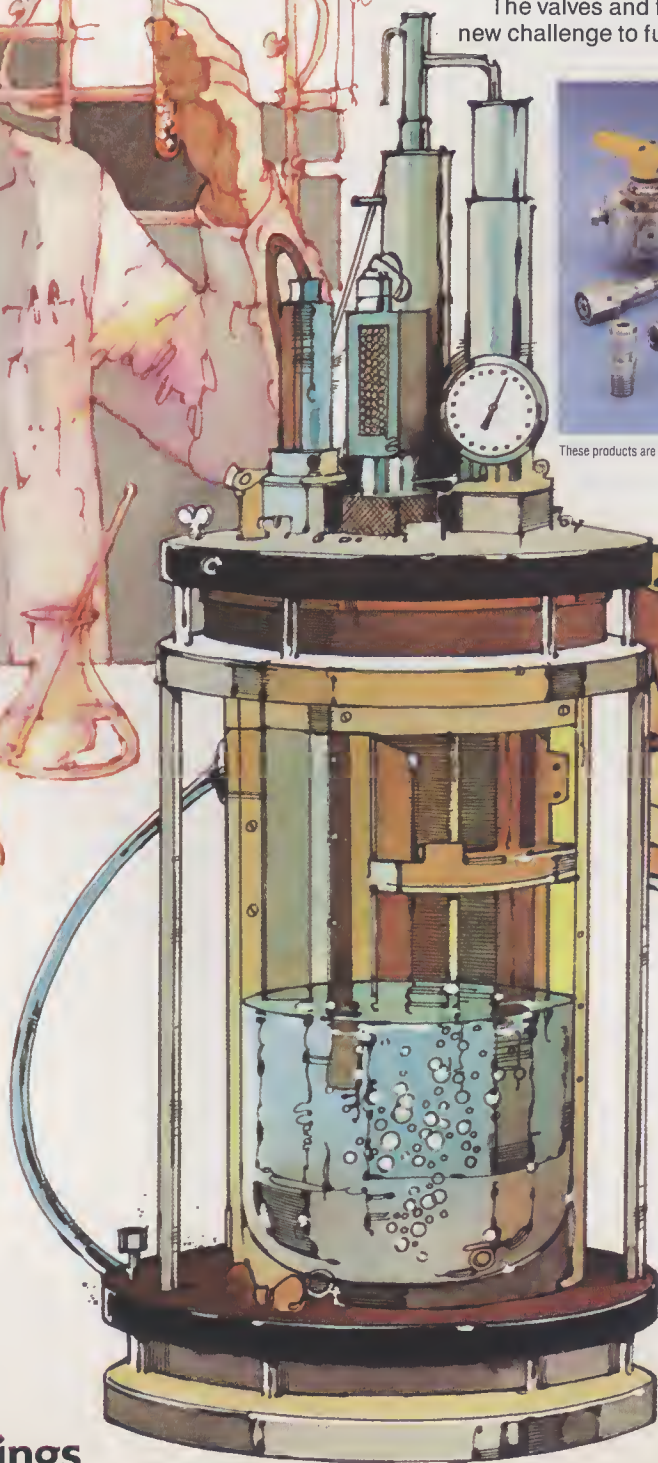
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